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Vol. XII MAY, 1907 No. 3

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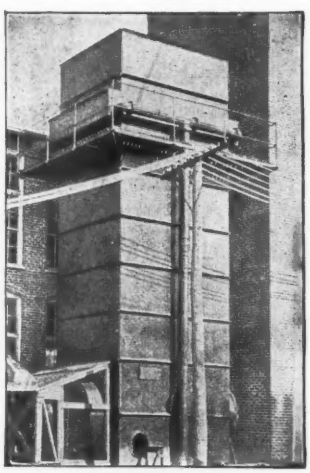

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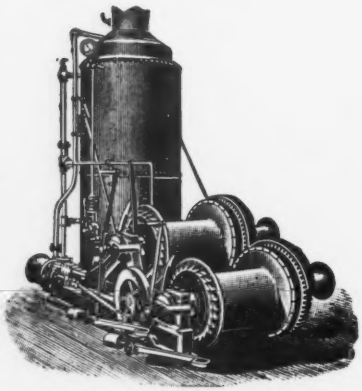

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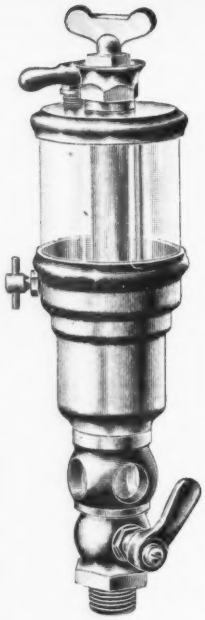

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MAY, 1907.

CONTENTS.

Well Drills for Blast Holes on the Panama Canal 4435

"Railroad Sand Craft" 4439

The Flow of Air in Long Tubes, With Special Reference to Pneumatic Dispatch 4444

Technical Publicity Association 4449

The Development of the Hammer Drill 4450

Editorials 4455

The Completion of a Year's Work.

Compressed Air on the Panama Canal.

Trade Publications 4457

Chippings 4458

What Pneumatic Tools Accomplish.

Industrial 4459

U. S. Patents 4460

WELL DRILLS FOR BLAST HOLES ON THE PANAMA CANAL.

By DeWitt.

The use of well drills for drilling blast holes was successfully demonstrated by "La Compagnie Universelle du Canal Interoceanique de Panama," generally known as "The Old Panama Canal Company."

During the period from 1886 to 1888 this company employed individual steam-driven well drills, which were mounted on two pairs of railroad trucks, four wheels each, of 1.5-meter (5-feet) gage. These drills used a bit of 12.5-c.m. (5-inch) gage. A number of these dismantled machines are still to be seen on sidings at Empire and Gorgona; no attempt has been made by the Americans to use these drills on account of lack of important parts of both machines and drilling tools.

The actual construction work by the French company was developed by benches of lifts of 5 to 6 meters (16 to 19 feet) vertical height. The American plan of excavation by steam shovels made it advisable to work vertical faces of from 20 to 30 ft., and, as the material to be drilled on the upper level, which is now being removed, is a mixed formation of indurated clay and medium soft basaltic rock, and somewhat difficult to drill with rock drills, it was deemed best after a careful study of the clay and rock formation, and taking into account the depth and diameter of blast holes required for economical work, to use well drills for the purpose. Accordingly in July, 1905, an order was placed for ten drilling machines. These were delivered in November, 1905, by the Star Drilling Machine Company of Akron, Ohio. They were of the pattern known as No. O, or 250-ft. machine, fitted with 5x5-in. reversing engine and using 5⅝-in. diameter bit. They were equipped with the well-known spudding motion and without walking beam. These ten machines were erected and put into service in December, 1905, and have since been giving successful service continuously since that time, and are still in good condition.

At this time, December, 1905, there were about ten steam shovels in active operation on the Culebra Division, and a contemplated increase to fifty shovels within another year made it necessary to adopt a larger system of blast-hole drilling, so in January, 1906, there were purchased from the Austin Manufacturing Company of Harvey, Illinois, twenty of their No. 2 portable well-drilling machines. They are equipped with walking beam motion and have a capacity of 250 feet of 5⅝-in. hole. They have been in constant service.

In January, 1907, orders were placed for forty-five well drills, with 5x5-in. reversing engines, spudding motion, 4-in. diameter bits and capacity of 100 to 150 feet in depth. Forty-

three of this lot are now being delivered by the Star Well Drilling Company and two by the Keystone Driller Company of Beaver Falls, Pa. Twelve Star machines and the two Keystone machines have been erected and are in daily service, and at the present writing (May, 1907), there are forty-four well drills in successful operation on the canal work between the locks at Pedro Miguel and the locks and dam at Gatun, the major portion of them, however, being operated between Paraiso and Bas Obispo. In addition to the above well drills there are one hundred and ten (110) 3⅝-in. diameter cylinder rock drills in constant service.

It was early decided on account of the size of the work, to operate all drills, as far as possible, from central power plants, in order to reduce labor and cost of operating a large number of scattered boilers. Prior to October, 1906, all well drills were steam actuated. Since October, 1906, the drills have been run almost exclusively by air, except a few drills in isolated places and on night shifts. (Air compressor plants are not run after 5 o'clock P. M.)

The power is supplied by three compressor plants. No. 1 plant is located at Rio Grande, about one-half a mile south of the town of Culebra, and consists of two Rand Imperial type, 10 duplex steam, compound air compressors, each of 2500 cu. ft. of free air per minute capacity. Steam is furnished by a battery of six old French boilers of approximately 85 h.p. each.

WELL DRILLING MACHINES AT WORK ON THE CULEBRA CUT.

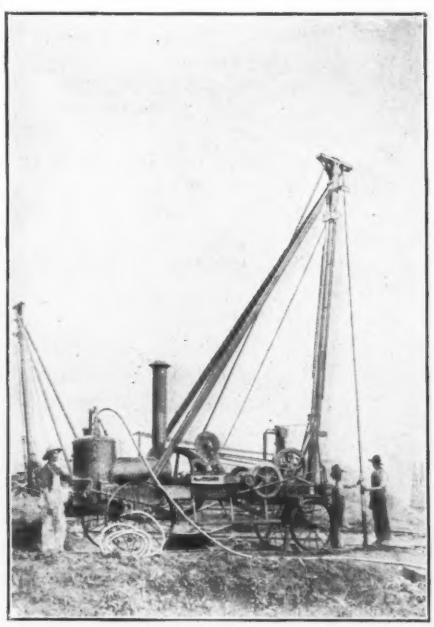
No. 2 plant is located at Empire (three miles from No. 1 plant) and is identical with the first-mentioned plant and in addition has two Laidlaw-Dunn-Gordon duplex steam compound air compressors of a capacity of 2500 cu. ft. of free air per minute, each. At this No. 2 plant the battery of old French boilers

is now being replaced by six Robb-Mumford 200-h.p. tubular boilers.

No. 3 plant, at Las Cascadas (two miles from No. 2 plant), is identical with the enlarged No. 2 plant.

The boiler plants furnish steam at 100 pounds pressure and the average air pressure at the plants is 90 to 100 lbs., the air pressure at the drills varies from 85 to 95 lbs. Drills will not work effectively on less than 75 lbs. air.

STARTING A HOLE.



DRILL IN OPERATION.

The three air plants, above described and having a total capacity when running full load of 25,000 cu. ft. of free air per minute, are connected with each other by a 10-in. wrought iron screw joint main pipe line laid outside the upper slope line and parallel to the center line of the canal. From the No. 1 plant the 10-in. line is extended to Pedro Miguel, one and one-half miles south; and from the No. 3 plant the 10-in. line is extended to Bas Obispo, one and one-half miles north, thus making an immense receiver 10 in. in diameter and eight miles long. At intervals of 1000 ft. along the 10-in. main line, 10x8-in. or 10x6-in. tees, with valves, are placed, a further reduction at the tee to 4-in. is made and a 4-in. line run to the canal prism. From these 4-in. lines a 2½-in. feeder is run inside the slope lines parallel to the center line of the canal and tees are placed at every second joint. From the 2½-in. feeder a 1½-in. or 1-in. branch is laid to the drill, and connection between the drill boiler, which acts as a secondary receiver, and branch pipe is made with a 25-ft. or 50-ft. length of Sprague armored air hose. At times it has been necessary to connect the hose directly with the air chest on the engine, and the result has been satisfactory.

The work of operating each air-driven well drill is done by a runner (who is usually a

West Indian or one of the native mixed Spanish types) and a helper. Drills, when steam-driven, require one runner, one helper and a fireman. Each two machines have one extra helper to look after the pipe line, hose etc. Two nippers are required on every two drills to carry bits to and from the blacksmith shop. Over every three machines is an American foreman and over every nine to twelve machines is an American general foreman.

Drill runners are paid from 25 cents to 38 cents, gold, per hour (nine-hour day). Drill helpers are paid from 16 cents to 25 cents, gold, per hour. American foremen are paid $125, gold, per month. American general foremen are paid from $150 to $175, gold, per month. American blacksmiths and drill sharpeners are paid from $125 to $175, gold, per month. Native drill sharpeners are paid from 50 to 60 cents, silver, per hour (ratio silver to gold 2 to 1). Native helpers receive from 26 to 40 cents, silver, per hour.

On the Empire section, where a larger part of the well drilling work has been done, the character of the material drilled varies greatly; from (1) a mixed clay and soft basalt formation, which material, while classified as soft rock, requires drilling and blasting before it can be handled by a 95-ton steam shovel, to (2) a very hard, fine-grained diabase or basalt, commonly known as trap.

The following figures taken from daily drilling reports show the relative variations in the work done by well drills using a 5⅝-in. diameter bit:—A Star drill working in the softer formation (1) has repeatedly drilled from 75 to 105 ft. of hole per nine-hour shift, while another machine of the same make, working some 800 ft. farther north and on the same level, but in the harder formation (2) has been able to make only 3 ft. per day for five days at a time, changing bits every two hours. These are extreme cases. Taking the average work done during the past seven months, using air as the motive power, the machines have averaged 28 ft. of hole each per nine-hour shift, as against 27 ft. per machine when the drills were steam-driven.

On high points many holes from 60 to 100 ft. in depth have been drilled. The average rate of drilling on these deeper holes has been about 23 ft. per shift. One Star drill at Mount Hope, near Colon, was equipped with a walking beam and has been used continually during the past year for sinking artesian well holes. Several successful holes over 600 ft. in depth have been sunk. Three drills were used at Pedro Miguel and two at Gatun for sinking holes from 70 to 100 ft. deep. These holes were cased and used by the diamond drillers in making tests for lock foundations.

On the ordinary work it has occasionally been found necessary to use casing where the top 6 to 12 ft. was of loose material.

The Star drills are run at an average speed of fifty-five drops per minute, the speed of the Austin drills is about forty-eight drops per minute.

There have fortunately been very few cases of lost tools, the number of accidents of this kind being less than on any similar large work that has come to the writer's knowledge. After extensive experiments with belting, it has been found that a two-ply water-proofed leather belting is the most serviceable and economical for this climate. The best quality hawser-laid manila drilling cable, when in continuous service, has a maximum life of four months.

The general method of drilling and blasting is to drill a single line of well drill holes, spaced 20 to 30 ft. apart and 24 to 32 ft. deep, according to height of shovel cut desired (and calculated to be at the bottom from 2 to 4 ft. below the required grade) and 18 to 24 ft. back from the face of the cut. In the hard rock sections a line of "toe" or "snake" holes 20 ft. deep are drilled with tripod rock drills, to reach a level with the bottom of the vertical holes.

Much of the material is somewhat difficult to blast on account of its tough clay-like character, but it is usually broken to a size which is readily handled by a 5-yard dipper on the 95-ton steam shovels. The larger pieces which cannot be so handled are reduced to suitable size by "mudcapping" or "doby shots." There are numerous hard, massive boulders found throughout the softer formations, which require drilling and blasting. Small air-hammer rock drills have been successfully used on these hard boulders and also in the quarries adjacent to the stone-crushing plants.

All drill holes are "sprung" or "chambered" with 60 to 75 per cent. dynamite, from one to four times, according to the hardness of the material.

It is customary to spring, load and blast a series of five to eight well-drilled holes, with the corresponding toe holes. All firing of

blast holes is done with electric batteries. On account of the climate and the perpetual damp condition of the ground, and recognizing the danger of handling black powder in the congested districts, it has been deemed best to discontinue its use.

In February, 1907, with twenty-three working days, there was more than 196,000 lbs. of dynamite and 46,000 lbs. of black powder used along the eight miles of the Culebra Division. During March, 1907, on the same division there were 14,904 linear feet of well-drilled holes put down, at a total cost of $5,557.65, or about 38 cents per foot.

"RAILROAD SANDCRAFT."

The Application of the Sand Blast to Railroad Service.

By J. M. Betton.

STEEL CARS.

The problem of painting the modern steel car has been before the Railway Master Painters since the introduction of this type of car some few years ago, and, with the increased use of steel cars, not only for freight, and with steel passenger cars already in use and bound to increase and in time supersede the present wooden coach, it becomes one of the greatest interest in the railway world.

The steel car is built by contractors controlling large plants especially adapted to this work. The material must be of the best, for the service-abuse of these cars is excessive—the ordinary wooden car would go to pieces under a tithe of it.

CLEANING.

This material to hold the paint, when exposed to the weather, should be cleaned thoroughly and all scale, rust, dirt and grease removed, and for this purpose it is admitted by the Master Car and Locomotive Painters' Association "that an up-to-date sand blast should be installed in the railway car building and repair department, also that its use in contract building shops be enforced."

SPECIFY SAND BLASTING.

Some of the contract building shops are equipped with sand blast outfits and are prepared to use them on their contract work, but the cost of sand blasting a car properly may be several dollars, and if this item is included in their estimate, it amounts to a very considerable sum in a contract for a thousand or more cars, and places the contract shop including it at a disadvantage against another shop which has no sand blast plant, has not figured on sand blasting, and is making a low figure in consequence. This matter settles itself when the railroads call for and insist upon sand blasting in their specifications and contracts, and the difference in expense is more than justified by the increased wear of the paint on such material.

CLEANING LOCOMOTIVE WORK.

In the locomotive paint-shop the sand blast can be applied to removing the old paint from tenders, doing as much work in one day as a dozen men can do with scrapers, stones and old files. Steam domes, sand-box casings, jackets, headlights, cylinder and steam-chest casings, steel cabs, and the like, are also readily cleaned with the sand blast, all old paint, scale, rust and grease being quickly removed, and the clean, gray metal left ready for the new paint.

SPEED.

Records show that the sand blast will clean cars at the rate of one square foot per minute, or, allowing for making ready the machine, refilling the tank with sand, and moving the hose, from 500 to 550 square feet per day of ten hours, and, after repainting, the car should hold its appearance and be free from rust for about five years, because the paint is applied to the clean surface, and there is no scale to flake off; nor rust, nor dirt, nor grease to prevent its adhering to the clean metal. Benzine, which is dangerous to use in the shop, scrapers and wire brushes, will not remove the obstructing elements in either the time or perfection of a sand blast, which is conceded as by far the best method of preparing new metal for painting, as it is also for removing the old paint and accumulations.

REMOVE RUST.

Rust goes on all the time until it is all removed or the material all gone, and paint applied over it cannot be depended upon while any traces of it exist. The sand blast searches the metal for rust as with a microscope and removes it thoroughly, while the best and most conscientious car painter can only get off slowly and incompletely with scraper, emery paper or coke rubbing this bane of the foreman car and locomotive painter.

QUALITIES OF SAND BLAST.

A sand blast to do this work must be well made, to stand the hard usage to which it is subjected. It must be easily filled, preferably with a shovel, and must be sufficiently portable to enable it to be moved about the work when required. It must give a sharp, strong and well-distributed blast, the sand and air being most intimately mixed, so that every grain of sand makes its record on the work, without undue scattering or waste. It must further be designed with some consideration for the cost of operation, and use the least possible air and sand.

Any sand blast will work if there is air enough behind it. On the shores of Cape Cod are many evidences of the sand's work on buildings, with glass dimmed and worn shingles or clapboards cut through, all indicating the cutting powers of this agent when backed by the uncontrolled force of the mighty winter winds, unlimited in quantity and untrammeled by man's devices.

COMPRESSED AIR.

In the modern manufacturing works the main object is to chain the forces of nature: steam, electricity and air, and to obtain from them the utmost benefit at the minimum of cost.

It is not so many years ago that air has been compressed and used again in mechanical processes, and, having been found a willing, convenient and valuable agent, its use has spread from one department of the works to another, each demanding a little more, until the capacity of the air compressor is soon reached. The sand blast is one of the applications of compressed air, and the Injector Sand Blast has been designed to fulfill the conditions above specified, and especially those of economy of air and sand.

THE INJECTOR SAND BLAST.

Sand blasts, as usually made, project the sand by one application of the air, a few with two, but in the Injector Sand Blast the air supply is subdivided into three parts, or jets, one of which in the center of the sand valve, creates a difference in pressure between that in the sand tank and in the upper part of the mixing chamber equivalent to that of a slight vacuum, causing the sand to flow with greater regularity, and it also scatters and mixes the falling sand.

The second, or mixer jet, acts on the flowing sand and mixes it more thoroughly, the flow of the sand being retarded by the peculiar construction of the mixing chamber.

The third, or forcer jet, conveys a further supply of air to this mixture of air and sand and sends it from the machine, through a carefully graduated orifice, to the delivery hose, terminating in a special nozzle of smaller diameter than the hose, which, by again retarding the current, adds to its velocity and force, the mixture, now at the maximum density of the air, striking the work with the greatest vigor and force, each particle of sand and air being utilized.

THREE-WAY COCK AND SAND VALVE.

The three air jets are controlled by one three-way cock and the flow of sand is regulated by raising or lowering the sand valve. Its operation is simple and easily controlled, and the machine can be operated by ordinary labor.

AIR PRESSURE.

For cleaning steel cars and locomotive work an air pressure of 30 pounds is recommended, the air and sand being distributed through a one-half-inch nozzle. When working under these conditions the sand blast will require 161 cubic feet of free air per minute, and this pressure, to give the best results, should be steady. If the air supply is taken from a main from which other supplies are taken, and the pressure is liable to fluctuate, a small receiver, about 18 inches by 30 inches, introduced in the air supply to the sand blast will not only give a steady pressure, but will catch any condensation from the air, which can be drawn off from time to time.

DRY AIR.

The air in the sand blast must be dry, otherwise the condensation from the sides of the tank will gradually percolate through the sand about the sand valve and cause it to cake and arch, stopping its flow. If this occurs, remove the sand from the tank and start over again with a new filling of dry sand, and remove the condensation by tapping the low point in the main air pipe, or pipe an "U," with a drip cock near the sand blast.

SAND.

Use good, clean, sharp sand, screened to remove material that would clog the sand valve or nozzle, and grade the sand to the

work. All sand should be dried by heat over a slow fire, care being taken not to burn it. If dried too quickly, or with too hot a fire, the sand will calcine and powder when it strikes the work. Allow the sand to cool for several hours before using. A hot sand creates steam in the sand tank, which will condense on the sides and cause delay.

Time the filling of the sand tank so that at the end of the day's work it may be left empty, as the sand will absorb moisture and may require to be removed in the morning.

AIR PIPING.

The air supply may be brought from any convenient distance, but the diameter of the pipe should increase from that of the connection to the sand blast, to allow for loss of pressure from friction, and in no case should the air connection be of smaller diameter than the connection to the sand blast.

HOSE.

The sand delivery hose may be of any convenient length and preferably of not too large diameter. With a medium size of hose the current of mixed sand and air is maintained at its maximum velocity through the full area of the hose, while in a large hose the maximum velocity is in the center, and in long lengths the sand will drop out of the current and fall to the bottom of the hose, especially if there are any pockets, this showing in the undue discharge of sand at times, until the hose is clear, when the normal flow is resumed.

PROTECTION.

The operators may protect their eyes and faces by helmets, masks of wire, goggles or veils, and, if the dust is excessive, an exhaust fan arranged to take the suction from the floor level of the sand blast room will be found very effective.

CLEANING BRIDGES AND STEEL WORK.

Outside of the shops and along the line the sand blast becomes an efficient means of cleaning old paint, rust, scale, and dirt from the steel structural work of bridges, viaducts, tunnels, and other structures.

The records of the sand blasting of steel structures in the United States are not numerous, and are summed up to the year 1903 in a paper on "Sand Blast Cleaning of Structural Steel," by George W. Lilly, Associate Member American Society Civil Engineers, printed in the Transactions of that Society, from which the following extract and notes are made:

ADVANTAGES OF SAND BLASTING.

"The greatest merit of the sand blast is that it removes from the surface of the metal every trace of dirt, scale, rust and grease, and the bright metallic surface is everywhere exposed and perfectly cleaned. This is an ideal condition to secure the strong adhesion of the paint, so that, as far as it is possible, it will protect the metal. The thoroughness of the cleaning effected by the sand blast is noted especially upon metal surfaces which have been pitted by rust and corrosion to a considerable degree. The pits are cleaned as thoroughly as other places. It also reaches and cleans effectually every portion in reentrant angles and on the edges of the different sections of a beam, girder, or post, on and around rivet heads, and in many other places either entirely inaccesible to the wire brush or steel scraper, or in which they are used with great difficulty and little effect. Such places cannot be cleaned thoroughly by hand, even with the most diligent effort. Even plane surfaces of considerable area on old structures requiring repainting, especially where covered largely with scale and rust, cannot be thus cleaned so as to remove all the dirt, rust, scale and disintegrating paint. There will still remain sufficient rust and scale to separate slightly the paint from the metal, so that there is not the intimate contact and firm adhesion necessary to prevent the rusting process. The continuity of the coat of paint will soon be broken at places, and moisture and gases in the atmosphere coming in contact with the metal, rust will be formed even under places where the paint remains intact.

"Paint applied to such surfaces can often be stripped off like the peel of an orange, and still remains tough and elastic."

The steel for the anchorages of the cables of the new East River bridge in New York was cleaned by the sand blast, as was also some of the steel in the Boston Subways. The bottom of U. S. S. "Atlanta" and some new plates for U. S. S. "Massachusetts" were cleaned in 1897 at the Brooklyn Navy Yard. The 155th Street viaduct in New York City, containing 600,000 square feet of painting surface, was also cleaned in the same year by the sand blast. In 1898 and 1899 the iron lock-

gates and a portion of the aqueduct of the Muscle Shoals Canal were cleaned by sand blasting. The Pittsburg, Cincinnati, Chicago and St. Louis Railway Company used the sand blast in 1899 in Columbus, Ohio, and at Akron, Ohio. The City of Columbus, Ohio, in 1901 and 1902, used the sand blast in cleaning viaducts in the vicinity of the Union Station, which had rapidly deteriorated from rust and the chemical action of the steam and gases from locomotives.

135,500 square feet of surface were cleaned under an average pressure of 35 pounds of air, with ½-inch nozzles and Lake Erie sand, at an average cost of about 3 cents per square foot, including the cost of labor, flagmen, air (which was paid for at the rate of 60 cents per hour for two machines in operation), sand, and drying, the average number of square feet cleaned per hour by one sand blast being 54. On this work it was found that a pressure of about 25 pounds of air did very efficient work where only light scale, rust spots and disintegrating paint were to be cleaned off.

The surface of the steel cleaned had about the appearance of frosted silver, and the paint covered thoroughly all portions, whether pitted or not.

The cleaning outfit was limited to two machines by the small capacity of the air compressor, and the conclusions deducted were that for ordinary cleaning of bridge and other structures, not subjected, as viaducts, to the blast and gases from locomotives, sand blast cleaning can be done at from 1¼ to 2 cents per square foot, a more perfect equipment being used.

CLEANING BRIDGES.

The Boston and Maine Railroad has used a portable sand blast outfit for cleaning bridges, under an air pressure of from 15 to 18 pounds, which was found very effective on weather rust not heavily scaled, with fine sand, coarse sand being used where the metal was pitted and the surface hard to get at. Three sand blasts were operated from a gasoline engine by a foreman and six men, three on the nozzles and three drying sand and refilling the machines.

NEW YORK SUBWAY.

The contractors of the Rapid Transit Subway in New York City used the sand blast for cleaning steel columns and girders of standard size and design, which had been delivered and piled exposed to the weather from eighteen months to two years, and on which, when ready to use, it was found that the paint had worn off considerably and a part of the steel was corroded. The air pressure was 65 pounds, the nozzle ½ inch, and the work was done by a foreman, two nozzle men, two sand men, and one laborer to assist the nozzle men in handling the hose. The plant was stationary and the steel was brought to it by a traveling crane.

In some of the instances mentioned the work was done under conditions more or less crude, and it is apparent that better results could have been obtained at less cost had the working outfits been better proportioned to the work.

SAND BLAST OUTFIT.

The sand blast outfit for cleaning structural steel work on railways should include two or more sand blasts, size 24 inches by 24 inches, an air compressor driven by a gasoline engine, an air receiver of ample size, a gasoline tank, the necessary air hose, delivery hose, nozzles, helmets, wrenches, spanners, a set of machinist's tools; including a set of pipe dies and stock, pipe vise, a number of lengths of iron piping of various sizes for leaders, a selected lot of pipe fittings, a sand drier and screens, ladders, ropes and tackle, and a swinging painters' stage.

SPECIAL CAR.

This outfit may be installed on a flat or derrick car and covered with a housing, but as the opportunities for operating it from the car must be limited, all should be readily removable and capable of being erected on the ground convenient to the work.

SETTING UP.

The engine and the compressor are set up, the air receiver connected, and from this the air line is led to and across the structure to be sand blasted. The air piping should be of as large area as is necessary to deliver the air at the farthest point without loss from friction. It should have reducing tees piped in about every fifty feet, from which the delivery to the sand blasts can be taken, as these machines are moved along the work, and if there is condensation in the piping it can be largely removed from one of these outlets between the air receiver and the sand blast.

The sand blasts can be set on the ground beneath the structure, on the structure itself,

or suspended on staging; but it will be found more convenient to keep them on the ground on account of greater ease in filling, and the current of sand and air is as readily delivered above the sand tanks as below, the pressure being increased according to the height.

SAND DRIER.

The sand drier may be of hopper or cylindrical pattern encircling a common stove, or a flat pan, the first being preferable, as the sand falls when dried through holes left in the bottom of the hopper, and does not require hand tending to prevent burning, as with horizontal driers.

AIR COMPRESSOR.

The air compressor, of compact, strong and durable design, either single or duplex, and of any of the well-known makes, should be capable of compressing to a maximum pressure of 50 pounds per square inch 500 cubic feet of free air per minute, assuming that two sand blasts, each having a half-inch nozzle, are operated simultaneously, this pressure being sufficient to deliver the blast to a height of 150 feet above the sand tank.

PRESSURE.

For ordinary work and heights a pressure of 30 to 35 pounds will be ample and will remove all scale, rust, old paint, and dirt. The required amount of compressed air for different nozzles and pressures can be found in table on second page of cover.

ENGINE.

A gasoline or other engine is belted or otherwise connected to the compressor and may be of any of the commercial types readily found in the open market, of not less than 70 H. P. It is no economy to cut down either in the size of the engine or compressor, and the advantage of a surplus of either air or power may at times offset the slightly increased cost of a plant that can be called upon in case of need and be not found wanting.

AIR RECEIVER.

The air receiver should be steel, tested to at least 120 pounds air pressure, in dimensions about 30 inches to 60 inches, provided with drain cock, safety valve, pressure gauge, and, for railway work should have an especially large air outlet, at least 3 inches, to give an ample volume of air in the air pipe without reduction of area if needed for a long line, the outlet being pushed down for ordinary work.

SUPPLEMENTARY AIR RECEIVER.

On a long line of air piping a supplementary air receiver about 18 inches by 30 inches or 36 inches will aid materially in maintaining a steady volume of dry air.

LABOR.

This plant will require two nozzle men, one engine man, and two laborers drying sand and filling the sand tanks, and one foreman to regulate the flow of sand and generally oversee the whole work.

SUMMARY.

The foregoing describes briefly a sand blast outfit adapted to railroad work, which will clean any structural steel *thoroughly*, remove all rust, and leave the gray metal ready for the painter's gang to put on the protecting coat of paint.

THAT compressed air is regarded seriously by automobile manufacturers is shown by the system introduced by the Lozier people. The air is automatically compressed, and when required for the different purposes is supplied to the various systems. The automatic compressor operates from the exhaust of the engine through a pressure regulator, and the pressure may be controlled and maintained at any desired point up to eight pounds, indicated on a small air gauge on the dash.

One of the functions of air pressure is to drive the gasoline to the carburetor from the 27-gallon gasoline tank suspended from the rear of the chassis. The second use of the compressed air is to force lubricating oil from a 3-gallon tank suspended beneath the chassis to the dashboard oiler, obviating the necessity of frequently refilling the dash oiler with an oil can and funnel. When the supply in the dashboard oil reservoir is low, it is only necessary to open a cock, allowing the air to enter the main reservoir, and the oil is forced to the dash oiler.

The third use of the compressed air is to drive water from a special water reservoir to the water packets of the running brakes. This system is only used in hilly country or in touring abroad among the Alps and through mountainous regions. The system can be cut off by a special air cock until required, when by admitting the pressure to the water-brake system each application of the brake pedal causes a flow of water to the brake drums.

THE FLOW OF AIR IN LONG TUBES, WITH SPECIAL REFERENCE TO PNEUMATIC DISPATCH.

By B. C. Batcheller.

PART II.

Relative Economy of Compression and Exhaustion.

The economic advantages of operating a pneumatic tube by exhaustion over compression have been mentioned. It can be further illustrated by comparing one of the pressure curves of Fig. 6 with a similar vacuum curve that gives the same mean velocity. This has been done in Fig. 8. Curve A shows the initial pressures required to give a mean velocity of thirty miles an hour in 8-in. tubes of different lengths. The pressures are measured in pounds per square inch above atmospheric. Curve B shows the vacuum in pounds per square inch below atmospheric required to give the same mean velocity in the same tube. Curve A is the same as curve B, Fig. 6, drawn to a larger scale. The curves have been plotted from the following table and the table was computed by formula (18).

Mean Velocity, 44 feet per second.

Compression		Exhaustion.	
Gauge Pressure, Pounds per sq. in.	Length of Tube, Feet.	Gauge Pressure, Pounds per sq. in,	Length of Tube, Feet
2.01	5,000	- 2.	5,701
2.90	7,000	- 4.	12,142
4.35	10,000	- 6.	19,245
5.42	12,000	- 8.	26,751
6.87	14,500	-10.	34,096
7.18	15,000	-12.	40,274
10.50	19,707	-14.7	44,090
23.	30,377		

It will be seen that 10½ lbs. pressure will maintain a mean velocity of 44 ft. per second in a tube only 19,707 ft. long, while 10 lbs. vacuum will give the same velocity in a tube 34,096 ft. long.

The vacuum curve has a double curvature and is more nearly a straight line than the compression curve until it approaches the limit of a perfect vacuum, where it turns sharply upward and becomes vertical at the limit. The vacuum curve meets the asymtote of the compression curve at a perfect vacuum, or —14.7 lbs. In other words, if the law held to the limit, an infinite initial pressure would give the same mean velocity as a perfect vacuum.

The best measure of the relative economy of compression and vacuum methods of working is by comparison of the horse-power required to compress and exhaust the air to obtain the same mean velocities. For example, assume, as before, an 8-in. tube and a mean velocity of 44 ft. per second; the following table gives the theoretical horse-power for tubes of various lengths operated by the two methods. The horse-powers were computed by formula (25). The results are plotted in curves A for compression and B for exhaustion, Fig. 9:

8-inch Tube. Mean Velocity, 44 feet per second.

Compression		Exhaustion.	
Length of Tube, Feet.	Horse-power.	Length of Tube, Feet.	Horse-power.
2,500	3.93	5,701	7.89
5,000	8.24	12,142	15.59
7,000	12.01	19,245	23.35
10,000	18.35	26,751	31.57
12,000	23.13	34,096	41.14
15,000	31.35	40,274	54.21
19,707	47.78	42,975	67.59
30,377	121.17	44,090	135.60

Thus, it will be seen that the advantage on the side of vacuum working is considerable. A tube 20,000 ft. long, or a little less than four miles, requires double the power to operate by compression than it does by exhaustion. The reason for this difference is to be found in the fact that the friction of the air increases with its density. By rarifying the air, the friction is reduced and consequently the power expended at the pump.

The vacuum horse-power curve B rises abruptly as the limit of a perfect vacuum is approached, but this part of the curve is beyond the limit of practical operation, so need not be considered. Up to lengths of 37,000 ft. the curve is nearly a straight line, which shows that the power required in vacuum working is nearly proportional to the length of the tube. This is far from true of compression.

PRACTICAL APPLICATION OF THE FORMULÆ.

In the foregoing formulæ we have a statement of the relations between the pressure, velocity, power and dimensions of the tube for

a constantly flowing current of air when the tube is straight, smooth and uniform in cross-section, with nothing to obstruct the free flow of air. No allowance has been made for the effect of the carriers, the retardation of bends and other disturbing elements, which in a practical system must be taken into consideration. These secondary, but none the less important, factors are irregular and some of them constantly changing, as, for example, the relative velocity of the carriers and the air current. They can be determined only by experiment and are usually expressed by emperical formulæ or co-efficients.

Carrier Velocity.—Pneumatic dispatch tubes may be operated in two ways: The initial pressure or vacuum may be maintained constant, in which case the speed of the air and the carriers will vary with the number of carriers in the tube at any given time; or the weight of air flowing per unit of time may be kept constant, resulting in fluctuations of initial pressure or vacuum, according to the number of carriers in the tube. The first may be termed a constant-pressure method; the second, a constant-velocity method—although the mean velocity of the air is not quite constant and independent of the number of carriers in the tube, but so nearly so that it may be considered constant for all practical purposes.

The constant-pressure method is used when several tubes are operated from a common reservoir, as, for example, the cash-carrying systems in stores, and the London telegraph system. The disadvantage of this method lies in the fact that the work done is not proportional to the load, the more carriers that are placed in the tube the slower they move until the number becomes so great that the tube is stalled. If two or more tubes are drawing their power from a common reservoir, the heaviest loaded tube takes the least powre, while the reverse should be the case. On the other hand, with the constant-velocity method the power required fluctuates with the load; as the number of carriers are increased the pressure or vacuum increases accordingly. If using vacuum the tube may be stalled when the force necessary to move the carriers exceeds a perfect vacuum, but with pressure above the atmosphere there is no limit so long as there is sufficient power available. It is usually desirable to have the speed of the carriers as uniform as possible, independent of the number in the tube. If the friction of the carriers is considerable, there may be some variation in the final velocity with which they arrive at the end of a long tube, and this variation increases with the diameter of the tube, because the pressure required to move the carriers bears a greater ratio to the pressure required to move the long column of air. Suppose that a large number of carriers are moving in a tube at a given time under 10 seconds' headway, and that suddenly no more carriers are dispatched; the presence of these carriers has caused the initial pressure to rise several ounces or pounds under the constant-velocity method of operating; as the carriers arrive at the end of the tube, the load is reduced and the air in the tube expands, causing the later carriers to travel toward the end of their journey with a greater velocity than the first. The reverse effect takes place when a large number of carriers are dispatched in a tube in which none were traveling.

In practice the carrier never has the same velocity as the air current that propels it, unless it is provided with a packing that fits the tube very closely, and that is seldom the case. Usually the diameter of the carrier is somewhat less than that of the tube, which leaves a space through which the air can pass, and the velocity of the carrier is reduced below that of the air in proportion to the amount of air that escapes past it.

If u equals the velocity of the air current at the carrier, u_c the velocity of the carrier, and d the co-efficient of slip, then

$$d = \frac{u_c}{u}$$

Or,

$$u_c = du$$

Carriers are sometimes provided with expanding packing that prevents any escape of air, in which case d equals unity, but usually d is less than unity, and as the carrier wears its value becomes less. To be accurate, values of d must be determined by experiment. The following are the results of several experiments:

Experiment One.

Smooth brass tube, inside diameter	2.180 in.
Carrier, brass with felt heads, diam	2.000 in.
Difference	0.180 in.

Vacuum = 0.75 lbs. approximate; weight of carrier = 0.406 lbs.; d = 0.60.

Experiment Two.

Smooth brass tube, inside diameter...2.055 in.
Carrier, brass, with felt heads, diam...2.000 in.

Difference ..... .055 in.

Vacuum = 0.75 lbs. approximate; weight of carrier = 0.406 lbs.; d = 0.92.

Experiment Three.

Bored cast iron tube, inside diam....6.125 in.
Carrier, with bearing rings compressed cotton and rubber, diam.....5.984 in.

Difference .....0.141 in.

$p_1 = 19.89$ lbs. absolute; $p_2 = 17.52$ lbs. absolute; L = 2992 ft.; weight of carrier = 8.344 lbs.; d = 0.94.

Experiment Four.

Tube and carrier same as Experiment Three. $p_1 = 17.44$ lbs. absolute; $p_2 = 15.13$ lbs. absolute; d = 0.92.

In the absence of experiments, the value of L can be roughly computed from formula for the flow of air through an orifice, considering the opening between the tube and carrier as an orifice. The difference in pressure in front and in rear of the carrier can be computed from (33).

Carrier Resistance.—The data usually given upon which to construct a system of dispatch tubes is the dimensions of the tube and the mean velocity of the carriers, from which must be computed the pressure, the quantity of air, the horse-power and such other information as may be required.

From the mean velocity of the carrier and the value of L the mean velocity of the air, u_m, is obtained by (32). Then substituting u_m in (18) and solving for the initial pressure, p_1 (or final pressure, p_2, in case of vacuum working), we have the pressure necessary to maintain the flow of air with no carriers in the tube.

In Fig. 10 let AB represent a tube in which a constant current of air is flowing from A towards B, with a carrier in the tube at C. The pressure is represented by the curve *ab*, which steps down abruptly at *c*, on account of the friction of the carrier.

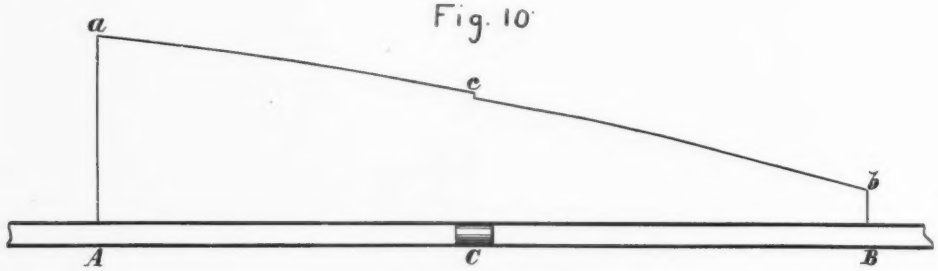
Let w = the weight of the carrier.

β = the co-efficient of friction of the carrier.

A = the transverse sectional area of the tube;

Then the air pressure per square inch necessary to keep the carrier moving with uniform speed is—

Fig. 10



$$p_c = \frac{\beta w}{A}$$

This is the height of the step at *c* in the curve. The pressure p_c is the difference in pressure in front and in rear of the carrier. If there are to be n carriers in the tube at the same time, then the pressure necessary to keep all the carriers in motion will be

$$np_c = \frac{n\beta w}{A}$$

This must be added to the initial pressure,

p_1 (or subtracted from p_2, in case of vacuum), which is necessary to give the required air velocity when there are no carriers in the tube.

For carriers with felt heads sliding in a smooth brass tube ,such as used in cash-carrier systems,

$$\beta = 0.48$$

For a light leather carrier in a smooth brass tube

$$B = 0.39$$

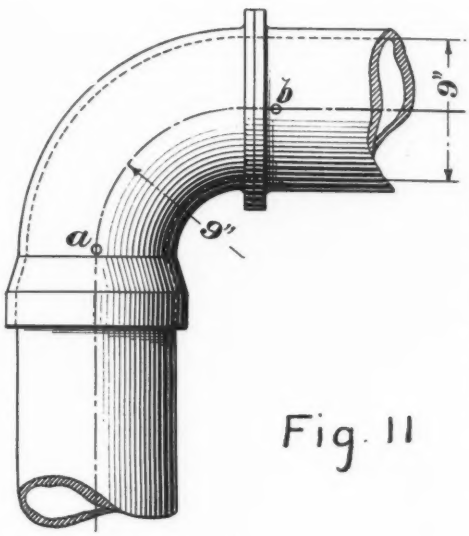


Fig. 11

For a 6-in. or 8-in. carrier, with bearing rings of compressed cotton and rubber sliding in a bored cast iron tube

$$B = 0.40$$

Resistance of Irregular Conduits.—Changes in the direction or velocity of the air current causes resistance to the flow, which is usually expressed by a loss of pressure. The curves in the tube through which the carriers pass are usually of such a long radius that they can be considered as straight tube, but there are often short elbows and branches in supply pipes leading from the air compressor to the tube, which must be considered, and the air has frequently to flow through lantern openings in entering and leaving the tube, that offer considerable resistance. If the supply pipe is long, its resistance can be computed by the same formula used for the tube. The additional resistance of each elbow and lantern opening can be estimated separately. For example, the pressure on each side of a 90° elbow of a 9-in. pipe, in which the mean radius of curvature is 9 in., was found to be 11 in. and 11.0184 in. of mercury, respectively, when the velocity of the air was about 45 ft. per second.

The elbow is shown in Fig. 11. *a* and *b* are the points where the pressure was measured. Another example gives the loss of pressure due to the resistanc of lantern openings in a 6-in. tube. The pressure at *a*, Fig. 12, was 0.49 lbs. per square inch and at *b* 0.34 lbs. The velocity of the air was 60 ft. per second. The cross-section of the air passage was at every point at least equal to that of the tube.

The resistance of the pipes, including elbows, tees, lantern castings, etc., that convey the air from the compressor to the tube or from the tube to the compressor expressed in loss of pressure should be added to the initial pressure of the tube proper, or, in case of vacuum, subtracted from the final pressure, and it should not exceed 10 per cent. of the loss of pressure in the tube. This should also include the resistance of passages from the tube to the atmosphere.

Quantity of Air.—The volume of air in cubic feet at atmospheric pressure that will flow per second is computed by multiplying the velocity of the air at the open end of the tube by the cross-sectional area of the tube, the velocity having been computed by formulæ (13) and (19). If air is taken from the tube for any purpose, such as the operation of

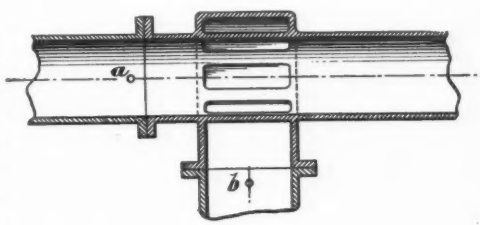


Fig. 12

dispatching or receiving apparatus, or, if there is any escape at other points than the end of the tube, allowance should be made for this.

Power.—Having computed the initial pressure or vacuum at the compressor and the quantity of air required, it becomes a simple matter to compute the horse-power by use of formula (26), making proper allowance for the efficiency of the compressor.

Referring to formula (33), if β w is the force required to keep a carrier moving, the horse-power required to move it with a velocity of u feet per second is

$$\frac{\beta \, w \, u}{550}$$

and for n carriers

$$\frac{n \, \beta \, w \, u}{550}$$

which is the power absorbed by the friction of the carriers.

INTERMITTENT AIR CURRENT.

In all that has been said thus far in regard to the laws of the flow of air in long tubes, a constantly flowing current has been assumed. Dispatch tubes are, however, frequently operated by an intermittent current—*i. e.*, a carrier is placed in the tube, the air is turned on from a reservoir and turned off again when the carrier arrives at its destination. The foregoing formulæ do not apply to air flowing under these variable conditions; in fact, no rational formulæ have been constructed for a variable flow. When a valve is opened and air is allowed to flow into a long tube, work is done in overcoming the friction of the inflowing air against the walls of the tubes, in accelerating the air in the tube, in compressing or exhausting the air in the tube, and in overcoming friction of the air in the tube. Finally a state of constant flow will be reached if the supply is kept up for a sufficient length of time; then when the supply is shut off the current gradually ceases until the air in the tube comes to rest. It is hardly possible to construct a formula for mean velocity under such conditions. In starting the air current in an 8-in. tube four miles long some minutes elapse before the constant state is reached.

When a valve is opened between a tube and a reservoir containing air under pressure a pressure gauge attached to the tube shows a lower pressure at first than it does after a minute or two has elapsed, when the constant rate of flow is established. The same is true when the reservoir is exhausted.

The following table gives some observations on this point with a 2¼-in. tube 5523 ft. long. The pressures are in inches of mercury:

The time of transit of a carrier through a tube is less when the tube is worked intermittently than when it is worked continuously, if pressure above the atmosphere is used, but when vacuum is used, the time of transit is greater when the tube is worked intermittently than when worked continuously. The reason is this: The mean velocity of the air depends upon its density. When pressure above the atmosphere is used, the mean density of the air is less during the period of variable flow than after it has reached the constant state; on the other hand, with vacuum the mean density is greater during the variable period. The higher the effective pressure employed, the greater is the difference in speed. With 6 lbs.

Time after Opening Valve.	PRESSURE				VACUUM						
	1	2	3	4	1	2	3	4	5	6	7
15″	14 5	13.7	11.5	12.4	9.5	9.0	11.0	10.5	9.7	9 6	9.0
30″	16.5	14 7	12.7	13.0			11.5	11.7	4.5	11.5	9.2
45″	17.0	15.0	13.	13.2			11.7	12.0	12.0	11.9	
60″		15.2				9.6	12.0			12.1	
75″		15.7			9.7	9.7					
90″		16.2									9 5
105″		16.5						12.2	12.2	12,2	9.7
120″		16.7	13.2								
135″		17.2									10.0
150″	17.2					10.2					
165″							12.2				

effective pressure, for example, a carrier takes only 3 per cent. longer time with continuous than with intermittent working, whereas, with 14 lbs. effective pressure it takes nearly 6 per cent. longer time.

The following table gives the percentage of time that would be lost in transit by using the continuous instead of intermittent method of working:

Effective Pressure per square in.	Extra transit time beyond that occupied with Intermittent method. Per Cent.
6	3.1
7	3.6
8	3.9
9	4.2
10	4.5
11	4.7
12	5.0
13	5.4
14	5.7

Percentage of time gained by vacuum working with the continuous method:

Effective Vacuum per sq. in.	Time saved; per cent.
3	1.9
4	2.6
5	3.4
6	5.3
7	4.9
8	5.8

The relative advantages of the two methods of working a tube continuously or intermittently usually depend upon the economy of power and the capacity of the tube system to transport material. When only a few carriers are dispatched, and those at long and irregular intervals, the intermittent method saves a great deal of power; on the other hand, if a large number of carriers are to be dispatched during a long period of time the advantages lie with the continuous method. The intermittent method permits of reversing the air current and using one tube for dispatching in both directions.

Condensation of Moisture in the Tubes.

More or less moisture is precipitated in tubes laid underground, owing to the fact that the earth is usually lower in temperature than the atmosphere. It has been observed that the higher the pressure used the greater is the condensation, so that for long tubes requiring considerable pressure it sometimes becomes very troublesome. Most of the moisture is precipitated near the end of the tube where the air enters; therefore "drips" should be placed at frequent intervals in this part of the tube.

Take an example: Suppose the temperature of the atmosphere is 75° Fahr., and that the relative humidity is 80, a cubic foot of air then contains 0.00107 lbs. of water vapor. Now suppose the air enters a tube and is cooled to the temperature of the earth, say, 60°. At this temperature a cubic foot of air can contain only 0.00082 lbs. of water vapor; therefore the difference between 0.00107 and 0.00082 is 0.00025 lbs. from each cubic foot of air will be precipitated on to the walls of the tube.

There is seldom much trouble from this source in the cold weather, but in the latter part of summer the tubes are sometimes very wet, so that the water gets into the carriers if they do not close tightly. The difficulty can be partly remedied where double tubes are used for dispatching in opposite directions by causing the air from one tube to return by the other and so avoid drawing fresh air from the atmosphere.

(*To be continued.*)

TECHNICAL PUBLICITY ASSOCIATION.

The subject of "house organs" for manufacturing concerns was discussed at the regular monthly meeting and dinner of the Technical Publicity Association, held Thursday evening, March 28. Addresses were made by Stuart Benson, R. Wallace & Sons Mfg. Co.; David Gibson, Globe Machine and Stamping Co.; Henry M. Cleaver, Niles-Bement-Pond Co.; H. L. Myers, New York Leather Belting Co., and W. G. Snow, Meriden Britannia Co. Each one of the speakers is the editor of a successful publication published in the interests of the company he represents. In some cases the house organ has taken the place of advertising in the trade press; and in other cases space in the trade magazines has been used as before or merely to exploit the "house organ."

THE DEVELOPMENT OF THE HAMMER DRILL.*

By H. L. Sinclair.

No doubt those who are interested in mining or the improvements in mining machinery are aware that during the past three years many changes are noticeable in the methods used in breaking ground. Since the introduction of the first piston drills, many years ago, improvements have of course been made from time to time, but the general construction has been the same. While admitting that the cost per foot broken was, in many cases, higher than with hand drilling, operators have continued using the larger 3-in. to 3¼-in. machines in their crosscuts and shafts, and 2½-in. to 2¾-in. machines in their drifts, raises and stopes. At the same time there have been many complaints made against the operating and maintenance expenses.

Fuel costs in most mining camps were high and there was very little ground in a crosscut or a shaft which could be broken and mucked for less than $10 per foot. It was necessary to have a drill runner and helper for each machine, or, where two drills were worked in the same heading, two drill runners and a helper. The runners were supposed to be experienced men, both in the art of breaking ground and in keeping their drills in good running order, and were entitled to at least $4 for an 8-hour shift. In drift and crosscut work it was necessary to either work but one drill shift or handle part of the muck twice in order to give the runners a "set up." For these reasons it was no wonder that the costs of breaking ground ran into money, and the operators were at their wits' end to find means of cutting down the expense.

EARLY DIFFICULTIES.

In the stopes, raises and drifts the lighter 2¼-in. drills would give fairly satisfactory results, as they could, in a pinch, be handled by one man with a little assistance now and then from a mucker or timberman. Still, each drill, even when new, consumed 80 to 90 cu. ft. of free air compressed to 90 or 100 lb. receiver pressure, and the cost of fuel, coupled with the monthly repair bills, often made the mine manager wish he had never seen a machine drill. Then, too, he was caused no end of worry and trouble in getting good runners. One man would break as much ground as was expected of him, but in so doing would likewise break side rods, pistons, pawls, etc. Another would get along with few repairs, but would not get results, evidently from fear of breaking the machine.

One runner preferred one make of drill and another would not have it, so the manager was, to use a common expression, "in hot water all of the time." He could not have several different makes of drills on hand on account of the large stock of repairs he would be forced to carry, and as a consequence had to take such men as he could get and "break in" new runners. For these reasons he kept at the drill manufacturers with suggestions to cut down the number of parts in their machines and make them less complicated and more substantial. His suggestions were taken in good spirit, perhaps, but the machine makers were loath to make any changes whereby the repair bills would be materially lessened, as their real income came from this source.

The larger manufacturers had men covering every camp, and when it became known that a certain property would soon be equipped with a compressor, the manager was beseiged by drill salesmen who offered all sorts of inducements in order to get their machines introduced, knowing well that it was not a question as to what they would make on the original sale, but what orders would come to them for repairs later on. The compressor bought, the manager was forced to decide on some make of drill.

A decision once arrived at, it was seldom that he could be weaned from his first love, and henceforth would be known as a Sullivan, Ingersoll or Rand man, and would spend hours arguing with some fellow operator about the merits of his pet drill, while in his letters sent with orders for repairs to the manufacturer, he would probably accuse this innocent person of sitting up nights figuring how he could change parts of his machine so that the repair bills would mount up. I know one large operator who has been using a certain make of drill for nearly twenty years, but who is always complaining about the maintenance expense and threatens to make a change on the next plant he installs. About the time he is ready to purchase, if approached by the representative of a rival concern, he will

* Read at the meeting of the Colorado Scientific Society, February 2, 1907. Proceedings, Vol. VIII, pp 235-246.

argue for an hour or so on the subject and will probably conclude by saying: "Well, I guess I'll stay with the old machine. If I buy yours, I expect I would be jumping from the frying pan into the fire."

INTRODUCTION OF THE AIR-HAMMER DRILL.

As I said before, many changes have been inaugurated in the past three years in the methods of rock breaking, and from the subject of this paper you will naturally infer that I intend to show what results have been obtained by the use of the air hammer drill. Before offering any argument, however, on the advantages or disadvantages of this type of machine, it might be well to explain how the machine was first used in mining operations and how I came to be personally interested in its development.

About seven or eight years ago I was employed on a property where a great portion of the value of the ore lay in a 6- to 10-in. streak of honeycombed quartz which was frozen to the wall; in fact, the gangue, which made up the major portion of a 4-foot vein, contained little or no value. Our method of mining had been to strip the quartz and take it down on sorting sheets in a filled stope by the use of gads. This was rather slow and arduous work, but the value of the gold was sufficient to leave a small margin of profit, even after excessive hauling, freight and smelter charges were paid. At this time I had occasion to go East to a directors' meeting of the company, where the difficulty of saving the ore was fully explained and, in the discussion which followed, various methods of overcoming the obstacle were considered.

At this time the pneumatic riveting hammer was coming into general use in boiler shops, and one of the directors, who was of a rather ingenious turn of mind, suggested that a hammer of this sort might be brought into play; and by the use of a gad in place of the riveting tool, be used to take down the ore. While I did not think the plan would prove feasible, I consented to visit a boiler shop and even experimented at driving rivets in an effort to ascertain what the possibility might be of using them for the purpose mentioned.

At that time the hammers were not as well designed as they are to-day, and the vibration was so great that I was forced to express the opinion that excessive wages would have to be paid the miners to get them to use the tool. In considering the question, however, one very important point, which has since been brought to light, was overlooked, i. e., that there was much less "kick back" in operating the hammer against rock than against a rivet in the shell of a boiler. The reason for this difference in the action of the tool is probably due to the fact that after the first few blows of the piston against the steel, the elasticity of the boiler sheet is such that it seems to spring back a trifle after each blow of the hammer. As the steel recoils it meets the next blow half way on the rebound and a shock is caused which is very trying on the nervous system of the operator. It has since been proved conclusively that with the improved type of hammer there is very little shock or vibration to inconvenience the operator, and that the remedy does not lie entirely in the improved machines. The conclusion is that, with a gad made with the proper taper, at each blow of the piston the tool is forced into the crevice and remains there until the next blow is struck. This leaves the operator with but the natural vibration of the hammer to contend with. In the later types of machines the piston is made to cushion on live air on the back stroke, and no excessive jar occurs.

FIRST EXPERIENCE NOT ENCOURAGING.

The tools were, however, not put in use at the mine, and although I thought of the subject many times during the three or four years following, and before their trial as hitch cutters in various camps, it was not until nearly three years ago that I had the opportunity of trying them in Cripple Creek. At that time they were being tried for block holing and hitch cutting, and the tool used was a 12-in. hollow piece of steel with about 14 or 16 cutting edges. The manufacturers were claiming great results for both of these purposes and for drilling as high as a 4-ft. hole, finishing about 1⅛-in. in diameter.

It fell to my lot to attempt to drill a round of holes in a narrow stope in one of the Cripple Creek properties, and I must admit that the result of the test offered no encouragement. The makers of the machine had evidently based their somewhat astounding records on tests made in some very even-cutting soft formation; for, when the drill was operated against Cripple Creek phonolite, it was soon discovered that unless some very radical changes were made in the drill bits they would not do the work. The greatest difficulty was

experienced in getting the bits spread to a gage so that they would follow. Then, too, the cutting edges were so fine that it was next to impossible to temper them to stand for more than an inch or two in that character of ground.

Another difficulty developed in the construction of the drill bits. These were made of ⅞-in. hollow staybolt iron, with 6 in. of hollow steel welded to either end for a shank and bit. It was found that crystallization would take place at the welds and either the shank or bit would jump off in a very few minutes. I decided, however, that the machine could be perfected, and with the assistance of my father, who is a mechanical as well as a mining engineer, set about remedying the faults mentioned. We turned our attention at first to the steel, and after careful experiments found that the bits with six cutting edges cut faster and held their gage better than any other style. The cross bit was tried, but was discarded on account of its tendency to "rifle" a hole and "hang up" in crossing slips at an acute angle. We also found that with this shape of bit it was hard work to rotate the drill by hand in soft ground, and, while it cleared better, the six-tooth bits gave much better results. Sharpening tools were made for the six-tooth bits and little difficulty was experienced in drill sharpening after the blacksmith had acquired the knack of spreading the gage.

NECESSARY MODIFICATIONS.

Hollow steel was necessary in drilling down holes or flat holes in sticky ground, as it was essential to force part of the exhaust air through the steel to clear the hole of cuttings. The welded bits would not stand in hard rock, and we were in a quandary as to how we would overcome this difficulty, until it was discovered that a ⅜-in. hole could be drilled through a 4-ft. piece of steel in a gun-barrel lathe. We used this class of steel for some little time, until we found that we could purchase a brand of hollow rolled steel in Sheffield, England.

With these changes we were able to drill 4-ft. holes in any ground at a speed varying with the formation of from 1 to 10 in. per minute. In testing the machine thoroughly, however, we found that a cast-steel cylinder would crystallize easily and we were forced to change the material used in its construction to the best grade of steel shafting, forming the complete cylinder out of the solid metal.

We then found that it was next to impossible to get men who would hold the machine over their heads and drill uppers. One could not blame the drill runners, as it was certainly an awful task to set a man at, and only the very strongest could stand it for any length of time. The screw-feed machine mounted on a light drift column was tried, but finally discarded, when one of the manufacturers constructed an air-feed attachment. With this machine it was possible to "set up" and "tear down" in less than a minute and the drilling capacity of the machine was increased 100 per cent. Machines of this type were placed in all of the larger mines of the country, and it was soon found in competitive tests that they would out-drill any of the 2¼-in. machines.

The manufacturers of the old-line machines soon found that they were rapidly losing ground and began to experiment on the same line themselves. Several new companies were formed, principally by mining men who realized the advantages of the air-hammer drills, as compared with the piston machines, and during the past year many improvements have been made.

As this brings us down to the present time, it only remains for me to attempt to show why this new type of drill has come to stay, and wherein it possesses advantages over the old-line drills. This I will attempt to do by taking up each class of work separately.

ADVANTAGES OF THE HAMMER DRILL.

In the large crosscut or railway tunnel, the large piston drill still holds the advantage, as it is possible to drill deep rounds and break the ground far more economically and rapidly than would be possible with the small hammer type. Even in this class of work, however, there is a place for the small drill, as they can be used most successfully in block holing and in taking up bottom or trimming up the walls where projections are left, either on account of missed holes, or because the drill runner has miscalculated the load he had on a certain hole. They can also be used for drilling uppers in the roof for pipe hangers, or for putting in short relief holes in the heading where they will give the cut holes a better chance to break.

In shaft or winze work, however, they can

be used for drilling the full round of holes and even in the larger sized shafts, records show a saving which is simply astounding. To those who are familiar with this class of work, the reason is obvious. With piston drills, even in the hands of the best of runners, more time is lost in setting up, tearing down, lining up, cranking in and out of holes and in changing steel, than is consumed in drilling. Where the ground is even and breaks well, it is not so bad, but where slips are encountered frequently, and time is consumed in preventing a "hang up," or where the formation is such that a great many holes must be drilled to break the ground, the air-hammer drill has all the best of the argument.

The machine, steel and hose, can all be put into one bucket and the drill runner can be at work in five minutes from the time he goes on shift. The steel being loose in the chuck, he loses no time in changes, and he can start a new hole while a piston drill runner would be cranking out. Holes can be drilled in any direction and pointed to take advantage of any slip. No holes need be lost, as it is practically impossible to get a "fitchured" hole even in the worst kind of ground. All of the holes can be drilled to any depth desired, up to 4 ft., except in very heavy sulphide ore, and the sump holes can be put in in any part of the shaft.

With a piston drill, the runner may get a hole down 3 ft., and then get hung up, and rather than lose time he will take a chance on breaking the ground and start another hole. On this hole he may have no trouble and he will perhaps drill it 6 ft. deep. What is the consequence? When the shaft is cleaned up he will find he has no sump, or one corner of his shaft sticks out so that he is unable to get a set up which will enable him to drill his round to advantage. He may even have to drill a hole by hand and shoot it before he can get in to do any good with his next round. As a consequence, the shifts are thrown out and valuable time is lost. When timbering commences, the small hammer drill is indispensable for cutting hitches and taking out projections where they interfere with the sets, and for these purposes alone, will pay for itself in 30 days.

In a drift, a drill runner can either mount the air-feed drill on a column or, where it is possible to pull the cut out of the top, he can work with the air feed alone, and in any ordinary ground, one man can drill a round of holes in half a shift. Where the cut is pulled from the center or bottom, he can either drill the back and top cut holes off a bar or simply use a stick of timber and butt the air feed against it. I have known of one man breaking 42 ft. in 19 shifts in a drift in granite, and not only did he do all the drilling alone, but the tramming as well.

There is a diversity of opinion as to whether it is advisable to use a 2¼-in. piston drill or an air-hammer drill in this class of work, and a decision, from an economical standpoint, can only be obtained by actual tests. As a usual thing, however, the hammer drill can be used advantageously in all drifts where a 4-ft. round, bottoming 1⅛-in. will break without leaving any "guns." With a piston drill of the size mentioned or larger, it is possible to make more rapid progress but the cost per foot will probably be greater, as much more powder and air will be required and it is a hard matter for a drill runner to set up and tear down without some help from a timberman or trammer. In ground which breaks short, however, the piston drill usually has the advantage, as a larger hole is drilled and the powder can be gotten to the bottom of the holes where it belongs.

COST OF STOPPING.

In stope work the 2¼-in. machine does not have a chance against the air-hammer tool and the records on some of the Cripple Creek properties show that their stoping costs have been reduced one-half since the introduction of the small machines. Where the values lie in small streaks of very high-grade ore, the saving is enormous, as the stopes can be carried even narrower than by hand, as the drill can be run in any place a runner can get his body.

I installed a small machine for a leaser in Cripple Creek some eighteen months ago, and he informed me after his lease had expired, that the little drill was worth $1,000 a month to him. He was stoping on a 14- to 18-in. streak of 4- to 5-oz. ore and found that the ground was too hard to break by hand. He then put in a 2¼-in. machine and was forced to carry his stope 3½ to 4 ft. wide. In doing this he lowered his values to $30 to $35 per ton. After the installation of the little air-feed drill, he was able to break one-third more ore in an 18-in. stope than he had with the

2¼-in. machine in one 3½ to 4 ft. wide. He ran his values back again $80 to $90, cut his hoisting and powder bills down to one-half, and and his timber to one-third, and yet kept his production up to more than the tonnage he was able to get back of the 2¼-in. drill. With the piston machine his air cost him $3 per shift, while with the hammer drill the charge was but $1 for the same length of time. He figured the difference in net returns and found that the small machine saved him a little more than $1,000 per month. The usual method of operating the machine in an open stope is to put in a couple of light sprags well up to the back and about 10 or 12 ft. apart. By putting a 2x12-in. plank on the timbers and drilling from it, a drill runner can fill a stope full of holes in half the time he would consume with a larger drill. Not only can he drill more holes, but he can drill them in any place he desires and take advantage of every slip.

The same method is used in upraising, and data furnished by some of the largest mines in the West shows that a saving of 50 per cent. can be readily given as the average.

REPAIRS.

Not only can more work be done with the hammer drills than with piston machines, but the saving in repairs is well worth considering. In nearly all of the small hammer drills, there is but the one moving part and when properly made this should last for months. The rotation being accomplished by hand, there are no pawls or springs to break and no rifle nuts to wear out. As the machines are fed by air, no feed screws or nuts are required. Taken as a whole, with a properly made air-hammer drill, the repairs are less than 25 per cent. of those of a 2¼-in. machine.

Working at a drill pressure of 100 lbs., a 2¼-in. machine requires 100 cu. ft. of free air per minute, while an air-hammer drill of the valveless type uses but 25 cu. ft. at the same pressure.

Another advantage possessed by the hammer drill lies in the fact that it is not necessary to employ a first-class drill runner, as a good miner who knows how to point his holes will do just as much work after two or three days' experience, as the best man one could hire.

While I could, perhaps, describe the various machines of this type manufactured, and give my ideas regarding the merits and defects of the different drills now on the market, I believe that it would be wise to confine my remarks to the air-hammer drills in general and concluded by saying, as the "old toper" did of brands of whisky, "that they are all good, but some are better than others."

A novel method of utilizing compressed air is described in *Prometheus,* a German scientific periodical. It is especially intended for application to the transport of live fish on railways. Experience has shown that in this connection it is necessary, not, as is usually done, to change the water frequently, but to promote a continuous current of air through it, and it is on this principle that the "compressed air tube" system is based. The open tank containing the water and fish is mounted on a covered railway truck, and air, drawn through a filter outside the car by a small pump, is carried to a horizontal tube or receiver of special composition lying along the floor of the tank, whence it is forced upwards into the water. The air is then allowed to escape at the top. The materials composing the tube are said to impart a special quality to the compressed air. The air pump may be driven either from one of the axles of the train, or by a small engine, but in the former case there is the risk of the supply of air failing when the train stops.

One of the dangers in air compression which has not been fully recognized until within a quite recent period is the liability to explosion in air-compressor cylinders when the heat of compression is caused to exceed the flashing-point of the oil used for cylinder lubrication. Several more or less serious accidents of this nature have been recorded within a period of three of four years.

"It is a well-established fact," state a prominent engineering journal, "that a compressed air system, that is, the air compressor, receiver and discharge pipes, has within itself the potentiality of destructive explosion if the matter of air-cylinder lubrication is indifferently attended to."

It is stated that the proposition for the supplying the entire Cobalt camp (Canada) with compressed air will be carried out. The scheme embraces the using of hydraulic power on the Montreal river to compress the air, which then will be piped to the camp.

COMPRESSED AIR

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W. L. SAUNDERS, M. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., Assoc. Am. Soc M. E., Managing Editor
P. F. KOBBÉ, JR., . . Business Manager
F. J. ROHDE . . . Advertising Manager

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THE COMPLETION OF A YEAR'S WORK

With this issue of COMPRESSED AIR the present management completes its first year in the conduct of the paper. The present issue also marks the completion of the term of service of the present Managing Editor, who leaves the paper, not without regret, but with the feeling that the work will be carried on certainly as efficiently as before and, he hopes, much better. He has had the privilege of seeing the paper grow at a most remarkable rate. The number of subscribers has increased over three hundred per cent. and the advertising pages have increased to a satisfactory degree. But, more gratifying than either of these, is the fact that the paper itself seems to have met with the approval and favor of its readers as shown by the numerous letters recently received from prominent engineers containing, it is true, much valuable and, sometimes, strong criticism, but on the whole they would indicate that COMPRESSED AIR as an engineering periodical has maintained its reputation as a valuable and interesting paper.

We sincerely hope that in the future the paper will continue to be able to publish articles of real value and worth, and with the amount of material already on hand, the outlook is exceedingly bright for the accomplishment of this purpose. In order, however, that COMPRESSED AIR may serve its readers to best advantage it is necessary that there be cooperation, and that they send us from time to time accounts of new ways for utilizing compressed air to advantage in the various lines of work in which they may be engaged. If you have succeeded in making a difficult repair by means of pneumatic tools, write us about it and send photographs. By establishing a precedent in these matters, others will be induced to follow your example, and you may obtain many valuable pointers which will greatly assist you in your work.

COMPRESSED AIR ON THE PANAMA CANAL.

The system for furnishing compressed air for the power on the Canal work is now well advanced, the Culebra plant and the one at Empire have been in operation for some months past with gratifying results, while the new plant at Las Cascadas is expected to begin running in a short time.

Good progress has been made in laying and connecting the giant 10-inch air line, and when completed this will extend all the way from Pedro Miguel to Bas Obispo, a distance of over ten miles. The pipe used in this line is of extra heavy wrought iron, ten inches in diameter and tested to withstand a pressure of eight hundred pounds to the square inch. It is believed this pipe will last even under the extreme climatic conditions that prevail on the Isthmus, for a matter of twenty-five years or more.

This air line constitutes the great artery or feeder through which the compressed air is forced, and presents an everready, bottled-up energy of tremendous working force and almost unlimited power; a force that can be tapped at a moment's notice and supplied at will to any and all parts of the work where power of this character is needed. It follows the line of the canal closely and at convenient intervals gate valves and tees are placed, from which branch lines of various-sized pipe con-

vey the air direct to the work. These can be shifted as emergency demands or new ones added, and with the aid of rubber hose present an almost continuous front of power units, equivalent to a long row of stationary engines placed side by side for a distance of ten miles. It is so arranged that this power is available as fast as the line is extended—a feature of immediate importance, as new drllls can be hard at work within the expiration of thirty minutes thereafter.

When the two compressor plants at Empire and Culebra were first installed, old marine boilers used by the first French Company were exhumed from the jungles and pressed into service temporarily. With these the compressors have for many months been furnishing motive power for operating the rock crusher plants, rock drills, well drills and for various other purposes, including the testing of air brakes and power for driving pneumatic tools, such as trip, clip, and riveting hammers, used in boiler and machine shops.

The rock drills usually sink shafts for blasting to a depth of from fifteen to twenty-five feet; while well-drill borings are sunk from one hundred to two thousand feet as the case may be, Of the rock drills there are one hundred or more of the new Ingersoll-Rand type in operation. while many of the old "French drills" of the Ingersoll pattern are likewise used and are still capable of doing good service after many years of idleness in the jungle. The operation of drills by compressed air adds greatly to their efficiency and overcomes many of the difficulties experienced where steam is the motive power, not the least being the facility with which air can be conveyed to the most inaccesible point—no matter how distant from the plant itself or point of contact with the main pipe line; points to which it would be inconvenient and economically difficult to apply steam power. The latter rapidly condenses as the distance increases and is not available at all for practical purposes outside of a five hundred foot radius from the boiler by which it is furnished. Another great advantage, as compared to steam, is that compressed air is almost impervious to heat and cold after it has left the receivers and the line can be carried under or over ground; along the bed of a river or other body of water, and still not lose an iota of its effectiveness.

Twelve new and complete sets of horizontal-return-tubular boilers of two hundred horsepower each have been ordered from the States, many of which are already on hand and are being rapidly set up. As fast as these are installed (two for each compressor, making a total of twenty-four in all) the old boilers are discarded; thereby adding materially to the efficiency of each plant. These new boilers will burn either coal or oil, and when the latter is furnished by the oil line, that now crosses the Isthmus, the initial cost of the production of compressed air will be reduced to a minimum.

When fully installed this system will comprise one of the largest compressed air plants in the world and should prove a most potent factor in the early completion of Uncle Sam's great waterway.

Under the able management of Mr. George D. Brooke; the Superintendent of Motive Power & Machinery for the I. C. C. and Panama Railway, and the personal supervision of Mr. James Monahan, Superintendent of Air Compressors, this work is being carried through to a successful conclusion. Mr. Monahan has had over twenty-five years experience in this line of work, usually in the capacity of directing and constructing engineer.

There are now installed, and in full working order, six large Ingersoll-Rand compressors (Imperial Type No. 10), each having a capacity of twenty-five hundred cubic feet of "free air" per minute. In addition to these six more of the same capacity will be added shortly, several of which are already on the ground and in process of erection.

The entire system is so arranged that the air line constitutes a continuous shaft or circuit, so that one or more compressors or all of them combined serve to force the air to the furthermost point in the line. After the air is compressed it is retained and cooled in large air receivers, whence it is conveyed directly to the main pipe or "air line" as needed. The compressors are automatically adjusted and at present maintain an average pressure of one hundred pounds to the square inch at the receivers, and with a very slight but gradual diminution this pressure extends the length of the line, that at the end being a fraction above ninety-five pounds or a trifle less than five pounds lost for the entire distance of ten miles.

TRADE PUBLICATIONS.

GOLDSCHMIDT THERMIT CO., 90 West Street, New York.—Handsome souvenir book, entitled "The Thermit Welding Process and What It Offers to Transportation Companies"; 20 pages, 9x12, fully illustrated and devoted to the applications of "Thermit" to the making of repairs of steamships, locomotives, car trucks, etc. This welding compound possesses many unique advantages, as it is entirely self-sufficient in its equipment, requiring no permanent installation of any kind for supply of heat or power; the equipment is light and portable; there is no limit to the size of casting that can be welded and welds made by the "Thermit" process are not only perfect joints but act as a reinforcement, since a collar of pure "Thermit" steel is fuzed around the broken part. This book should be very valuable to all those who are interested in making quick, inexpensive and permanent repairs.

CHARLES ENGELHARD, 41 Cortlandt Street, New York.—Fifty-six-page descriptive circular, 6x9, devoted to the design and application of the "Le Chatelier" Pyrometer. This Pyrometer is suitable for measuring temperatures between zero and 2920 deg. Fahr. It is constructed in accordance with the specifications of the Royal Physical Technical Institute of Charlottenburg.

THE HISEY-WOLF MACHINE CO., 150 Nassau Street, New York.—Catalogue No. 5, 28 pages, 4¾x6¾, descriptive of the full line of portable electric tools manufactured by this company. Full information is given regarding electrically driven grinders, breast drills, hand drills, radial drills, etc.

BUFFALO FORGE CO., Buffalo, N. Y.—Small leaflet describing the Buffalo Air Washer and Humidifier. This apparatus removes all dust and smoke from the air entering a ventilation system; regulates the humidity; reduces the temperature in summer over 80% of the initial difference in temperature between the air and the cooling water used; requires no attention or adjusting.

AMERICAN STEEL WIRE CO., The Rookery, Chicago, Ill.—*American Wire Rope News* devoted to the construction and application of American wire rope, also containing useful hints on the treatment and care of rope for elevators, yachts and ships.

INGERSOLL-RAND CO., 11 Broadway, New York.—Booklet No. 20 A, 20 pages, 11 illustrations describing the new Temple Ingersoll Electric-Air Drill. This novel device not only completely solves the problem of employing electricity in the driving of rock drills but avoids entirely the conditions which make the successful employment of the electric drill impossible. The drill is air operative, with special advantages of its own, particularly in the increased force of the blow struck and the great saving of power. It should be known by all who have any interest in rock cutting.

JOSEPH T. RYERSON & SON, Chicago, Ill.—*Ryerson's Monthly Journal and Stock List.* April issue of this valuable pamphlet contains articles on the care of locomotive boilers, novel method of making an extension to a large stack, credits and accounts, notes on riveting and many other subjects of interest.

H. W. JOHNS-MANDEVILLE CO., 100 William Street, New York.—Small leaflet describing the "J-M" Heater portable type for use in residences, hotels, public buildings, offices, theatres, steamships, drying rooms, ovens, etc. They are neat and compact and easily portable.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J.—April issue of *Graphite.* This paper contains an article which should be read by all compressed air users. It is entitled "Village Wrecked by Two Explosions" and contains some pertinent remarks on the proper lubrication of air compressor cylinders.

It has been found in practice that the speed of flow in the main compressed air line should not exceed 30 ft. per second. It the velocity exceeds 30 ft., the plant is not running on an economical basis, and the percentage loss will increase with the increase of the velocity. From 4 to 6-in. main lines are sufficient for ordinary practice in mines; a 4-in. line will deliver 480 cu. ft. of free air per minute, compressed to 85 lb., with a loss of 2 to 3 lb. for a line less than 3000 ft. This volume of air is sufficient to run four 3-in. drills. The line may be of cast or wrought iron. Wrought-iron pipes are usually connected by sleeve couplings. An inspection of the main should be made now and then and if the pipe leaks, it must be repaired at once as an air leak is more expensive than a steam leak.

WANTED.

Present address of Chas. G. Eckstein, formerly of Center Street, New York, or any manufacturer or U. S. agent of high pressure compressed air Manesman tubes or seamless drawn steel air receivers.

CHIPPINGS.

The loss of power in compressing air in a receiver and using it in an engine driven by steam would depend to a very large extent on the purpose for which the power was to be used, how far the engine was to be located from the air-compressor, and a number of other factors, but generally speaking, the efficiency is rather low. There are several sources of loss: first, the air-compressor itself, the efficiency of which would probably be 80 to 85 per cent.; second, loss occasioned by pumping the warm air of an engine-room in the case of a stationary plant, which, of course, would not be present if you refer to its use on an automobile; third, friction in the conducting pipes, this being excessive if the pipe is very long, as in the case cited by an engineer of a water-power air-compressor plant transmitting its power three miles to mining machinery through a 24-inch main; but 390 horsepower was delivered of 1,430 generated at the falls. In an extensive system of compressed-air distribution service used in Paris some years ago, it was found impossible to make a commercial success of it, unless the air were heated prior to use. It is also very difficult to entirely prevent losses from leaks. Experiments extending over a number of years have been made in this country with street cars using just such a system as you mention, *i. e.*, air compressed in receivers and expanded in double-acting engines similar to those used with steam. That they were finally discarded as commercially impracticable after long experiment and investigation would appear to conclusively demonstrate that the losses are excessive.

Gasoline air-compressors may often be employed advantageously in work that does not warrant the installation of a steam plant. A 3¼-in. drill will require about 12 h.p., or 12 pints (1.5 gal.) of gasoline, which, at price of 15c. per gal., would make the operation for eight hours come to $1.20, reckoning that the drill is run two-thirds time. There may be also saving in attendance, as compared with a small steam plant. Gasoline air-compressors have been successfully employed in mining work.—*Engineering and Mining Journal.*

If air at atmospheric pressure and 60° F. could be compressed to 100 lbs. gauge-pressure, and all the heat due to the work of compression taken away as fast as generated, so that the temperature during compression would remain constant, the mean effective pressure during one stroke of the air piston would be 30·2 lbs. If, on the other extreme, none of the heat due to the work of compression is taken away, the mean effective pressure during the stroke will be 41·6 lbs., and the terminal temperature will reach 485° F. As the power required for compression is directly proportional to the mean effective pressure, it will be seen that the additional power required in the latter case is 37½ per cent. of that in the former. In practice neither extreme can be reached, for it is impossible to completely cool the air during compression, and, on the other hand, some of the heat of compression will be radiated; but the lower extreme is the ideal, and the nearer it can be approached the more economical will be the work done.

WHAT PNEUMATIC TOOLS ACCOMPLISH.

What an immense gain was made when the wearied hand of man put the powers of nature to work to drive his tools for him. The conversion of the hand tool into a power driven machine marks a new era in man's economic history.

The annual reports of some of the leading pneumatic tool companies calls attention again to another of the revolutionary influences which power driven tools have introduced into industry. Two great industries have especially been effected by the application of pneumatic power to tool working operations. These are mining and the manufacture of steel structures, including the hulls of ships, bridge parts, and steel framework for large buildings. In mining, especially coal and ore mining, the greatest change effected has been to increase the volume of output by steam or pneumatic drills.

The progress of machine mining is illustrated by the report of the mine inspector of West Virginia. There in 1897 fifty-five machines were at work, and the production of coal by machine was a little over 600,000 tons. In 1905 1,158 machines were at work, and the total production was over 10,000,000 tons. In the first of these years 5.12 per cent. of the total coal produced was by machinery, and in the last year mentioned 32.75 per cent. Mean-

while the number of employes connected with the operation of mining machines increased from 652 to 10,137. In 1901 there were ten employes to every machine. In 1905 the ratio was about the same, so that machinery did not apparently in this case reduce the number of employes required, but maintained a more or less constant ratio of addition. In other words each additional machine called for ten additional employes.

The same result of increasing production comes from the use of power driven tools in working up manufactured materials. In the putting together of steel materials for structural purposes, pneumatic tools have been applied mainly in riveting. Yet invention in this single process has immensely cheapened the cost of operation. Other similar processes are likewise affected with similar results. As yet, however, outside of ship yards of the Great Lakes this reduction in the cost of production has apparently not affected our capacity to build ships in competition with foreigners.

Probably the main reason is that in the more progressive ship yards abroad all of our economizing devices have been adopted or adapted, with the result of introducing possibly greater economies than our own inventions have provided for home production. The German ship yards were quick to see the advantage of pneumatic tools in the construction of boilers and steel hulls. The English and Irish ship yards were somewhat slower, but this apparent disadvantage was overcome for the time being only by the greater amount of work for which a high degree of skill had been attained in hand operation.

The lesson to be drawn from this is that no modern country can make any great advance in the arts, whether by introducing mechanical economies or otherwise, without other countries availing themselves more or less promptly. Wonderful as the pneumatic tools are, they are no sooner invented and patented here than the American agent is sent into the foreign field to introduce them and put them in operation.

This is one of the phases of international competition which no tariff can regulate and no trade policy prevent. The age of machinery is dominated by an equalizing tendency in the instruments of economic competition. The greatest contributors to progress at home in the inventive fields are represented in other nations almost simultaneously. So that the actual working equipment of rival nations is not quite so difficult as some of our publicists would have us believe. The inventors and makers of power driven tools are among the world's greatest levelers. But they level up, and not down.—*The Wall Street Journal.*

INDUSTRIAL.

Goldschmidt Thermit Co. announces the removal of their offices from 43 Exchange Place to the fourteenth floor of the West Street building, 90 West Street, New York. Also that they have opened a branch office at 432-436 Folsom Street, San Francisco, Cal., under the management of Mr. L. Heynemann for business in the States of California, Oregon, Washington and Nevada.

Thomas W. Pangborn Co. announce that the continued rapid growth of their business makes it necessary to enlarge their general offices. They are now occupying a large suite of rooms on the fifteen floor of the new West Street building, located at West and Cedar streets, New York.

The Cleveland-Cliffs Iron Co. has placed an order for a 60-drill Sullivan air compressor for its new Mass Mine at Negaunee, Mich. The machine will be of the Corliss Cross Compound condensing, two-stage type, with large receiver intercooler. The steam cylinders will be 24x46 inches in diameter, with a 48-in. stroke, and the air cylinders 40x24x48 inches, with a displacement capacity of 4000 cubic feet of free air per minute, at 60 r.p.m., or nearly 5000 feet at 70 r.p.m. The compressor will be built at the Chicago works of the Sullivan Machinery Company.

Mr. J. F. W. Bunsen has entered the employ of Muralt & Co., engineers and contractors, New York, and will take charge of their Southern office in Charleston, S. C.

Mr. Bunsen, who is a nephew of the late Prof. Bunsen, the inventor of the burner which bears his name, has had many years' experience in designing and erecting important engineering works. At the time of the Galveston flood Mr. Bunsen was engaged as the mechanical superintendent of the American Cotton Co., Southern District.

Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

845,135. PNEUMATIC HUB FOR WHEELS. William S. H. Smith, Croydon, England. Filed Sept. 10, 1906. Serial No. 333,993.

845,265. AUTOMATIC AIR-BRAKE COUPLING FOR RAILWAY-CARS. Frank H. Rutherford, Chicago, Ill. Filed April 14, 1906. Serial No. 311,709.

845,275. PNEUMATIC RENOVATOR. Thomas J. Sullivan and George J. Harris, Wilwaukee, Wis.; said Harris assignor to John H. Stouthamer, Wilwaukee, Wis. Filed Nov. 25, 1904. Serial No. 234,303.

845,327. PNEUMATIC CUSHIONING WHEEL-SUPPORT. George W. Bell, Liverpool, England. Filed Feb. 12, 1906. Serial No. 300,560.

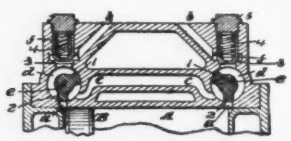
845,500. AIR-BRAKE APPARATUS. Rogert J. Wilson, Pittsburg, Pa. Filed Nov. 16, 1905. Serial No. 287,655.

Claim.—In an air-brake system, the combination of an auxiliary reservoir, brake-cylinder, triple valve and train-pipe, and an automatically-acting ball-valve for throttling the train-pipe.

845,562. APPARATUS FOR SEPARATING DUST FROM DUST-LADEN AIR-CURRENTS. Augustus Lotz, San Francisco, Cal., assignor to Sanitary Devices Manufacturing Company, a Corporation of California. Filed Nov. 14, 1904. Serial No. 232,659.

845,563. PROCESS OF SEPARATING COLID MATERIAL HELD IN SUSPENSION BY AIR-CURRENTS. Augustus L*tz, San Francisco, Cal., assignor to Sanitary Devices Manufacturing Company, a Corporation of California. Filed Nov. 14, 1904. Serial No. 232,660.

845,653. AIR-COMPRESSOR AND THE LIKE. George de Laval, Cambridge, and George P. Aborn, Boston, Mass., assignors to International Steam Pump Company, New York, N. Y., a Corporation of New Jersey. Filed July 15, 1904. Serial No. 216,682.



Claim.—In an air or gas compressor or pump, the combination with the cylinder and its inlet and discharge passages, of spring-closed puppet discharge-valves in the discharge-passages, mechanically-actuated valves between the puppet-valves and the cylinder controlling the discharge-passages, and means for actuating said mechanically-actuated valves to open the discharge-passages at a fixed point and to close the discharge-passages at the end of each compression-stroke and before the closing of the puppet-valves, and maintain the closing of the discharge-passages on the reversal of the piston, whereby a slow-closing movement of the puppet-valves is secured and the puppet-valves ar cushioned in closing, substantially as described.

845,736. COMBINED AIR-BRAKE-SETTING DEVICE AND ALARM. Robert E. Adreon, St. Louis, Mo. Filed Nov. 30, 1906. Serial No. 345,593.

845,841. PRESSURE-REGULATOR BELLOWS. Philip Wuest, Jr., Philadelphia, Pa., assignor to The Auto-Manuel Piano Action Company, Philadelphia, Pa., a Corporation of New Jersey. Filed Nov. 7, 1904. Serial No. 231,706.

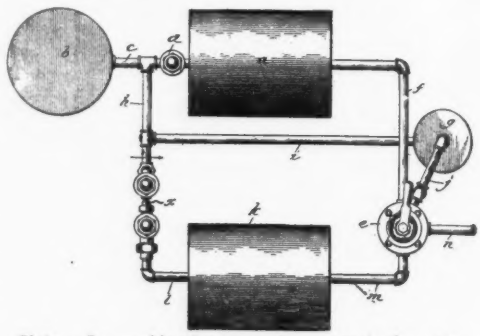
845,842. PNEUMATIC WHEEL. William L. Barnard, St. Louis, Mo. Filed Nov. 28, 1905. Serial No. 289,529.

845,952. DRILL OR BIT ROTATING MECHANISM FOR ROCK-DRILLING MACHINES OR ENGINES. Henry Hellman and Lewis C. Bayles, Transvaal. Original application filed July 12, 1905. Serial No. 269,408. Divided and this application filed June 12, 1906. Serial No. 321,328.

846,305. COMBINED TRAIN SIGNAL AND INDICATING APPARATUS. William A. Harris and Benjamain S. H. Harris, assignors to The Harris Manufacturing Company, Greenville, S. C., a Corporation of South Carolina. Filed March 23, 1904. Renewed June 6, 1906. Serial No. 320,450.

846,306. COMBINED TRAIN SIGNAL AND INDCAITING APPARATUS. William A. Harris and Benjamin S. H. Harris, Greenville, S. C., assignors to The Harris Manufacturing Company, Greenville, S. C., a Corporation of South Carolina. Filed March 23, 1904. Renewed June 6, 1906. Serial No. 320,451.

846,528. AIR-BRAKE SYSTEM. Walter V. Turner, Wilmerding, Pa., assignor, by direct and mesne assignments, to The Westinghouse Air Brake Company, Pittsburg, Pr., a Corporation of Pennsylvania. Filed Aug. 1, 1903. Renewed April 23, 1906. Serial No. 313,320½.



Claim.—In combination, a main reservoir for relatively high pressure, a supply reservoir for relatively lower or train line pressure, an application reservoir for a higher pressure than that of the main reservoir, means for maintaining the desired pressures in these reservoirs, a train pipe and an engineer's valve provided with service exhaust means and having connection to the three reservoirs and train pipe, and adapted to connect the main and supply reservoirs to the train pipe, and to connect the application reservoir to the service exhaust means, whereby such means are operated.

846,640. FORCE-PUMP. Charles Wolf, St. Louis, Louis, Mo. Filed Oct. 15, 1906. Serial No. 339,089.

846,857. PNEUMATIC TOOL. Herman Leineweber, South Chicago, Ill., assignor of one-half to W. M. Bayne, Chicago, Ill. Filed Nov. 6, 1906. Serial No. 342,179.

847,043. PNEUMATIC TOOL. E4ward B. Boyer, Peoria, Ill. Filed Jan. 2, 1906. Serial No. 294,119.

847,269. SAND-BLAST APPARATUS. Franklyn M. Wise, New York, N. Y., assignor to American Diamond Blast Company, New York, N. Y., a Corporation of New York. Filed Nov. 10, 1905. Serial No. 286,632.

847,270. SAND-BLAST APPARATUS. Franklyn M. Wise, New York, N. Y., assignor to American Diamond Blast Company, New York, N. Y., a Corporation of New York. Filed Nov. 23, 1905. Serial No. 288,641.

847,273. PROCESS OF DRYING AIR FOR BLAST-FURNACES. Nathaniel T. Bacon, Peace Dale, R. I. Original application filed Jan. 25, 1905. Serial No. 242,697. Divided and this application filed March 13, 1906. Serial No. 305,777.

847,373. PROCESS OF DRYING AIR FOR BLAST FURNACES. NATHANIEL T. BACON, Peacedale, R. I. Original application filed Jan. 15, 1905. Serial No. 252,697. Divided and this application filed March 13, 1906. Serial No. 305,777.

847,278. PNEUMATIC CLEANER. WILLIAM W. CONOVER, Toronto, Ontario, Canada, assignor to Sanitary Carpet Cleaner Co., a Company of New York. Filed April 26, 1905. Serial No. 257,547.

847,317. RECHARGING-VALVE FOR AIR-BRAKES. FRANCIS L. CLARK, Pittsburg, Pa., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Oct. 18, 1902. Serial No. 127,816.

Claim.—A recharging-valve device for air-brakes, comprising a movable abutment exposed on one side to train-pipe pressure and on its opposite side to a variable fluid-pressure, means actuated by a slight movement of the abutment caused by a slow and gradual increase of train-pipe pressure to open communication from the train-pipe to the auxiliary reservoir, and means actuated by a further movement of the abutment in the same direction to close said communication.

847,394. AIR-PUMP. JOHN C. BECK and JOHN A. BOWYER. Chicago, Ill. Filed Aug. 11, 1906. Serial No. 330,117.

847,433. AIR LIFT-PUMP. BRYAN OBEAR, St. Louis, Mo., assignor to Montague Compressed Air Company, St. Louis, Mo., a Corporation of Missouri. Filed May 14, 1906. Serial No. 316,872.

Claim.—In an air lift-pump, a suitable pump-cylinder, means for admitting thereinto the liquid to be pumped, a pipe leading into said cylinder and discharging air under pressure in a pet directed toward the discharge end of the cylinder, a check-valve located in the cylinder above the discharge end of the air-pipe, a branch leading into the cylinder from the air-pipe above the check-valve, a valve in said branch normally closed when said check-valve is open, and a suitable intake for the cylinder, substantially as set forth.

847,470. AIR-COMPRESSOR. WILLIAM E. GRAY, Winton, Va., assignor of one-half to John B. Beard, Vinton, Va. Filed July 24, 1906. Serial No. 327,528.

Claim.—In an air-compressing apparatus, a compressor-frame comprising a straight central discharge-pipe disposed longitudinally of the frame, straight lateral discharge-pipes disposed transverse to the frame at opposite sides of the central pipe and each having separate connection therewith, pump-cylinders disposed longitudinally of the frame at the respective corners thereof, each cylinder having each end of its inner side connected to a separate lateral pipe, an outlet-valve in each lateral pipe, inlet-valves located at each end of each pump-cylinder at the outer side thereof, and pistons within the cylinders, the several discharge-pipes and pump-cylinders being located throughout in the same horizontal plane to produce a flat rigid self-contained frame structure.

847,569. MEANS FOR COMPRESSING AIR AND THE LIKE. JOHN GILL, Edinburgh, Scotland. Filed June 3, 1905. Serial No. 263,676.

Claim.—In an apparatus for compressing air or other elastic fluid by means of a descending column of incompressible liquid the combination of a downward pipe *a* and an upward pipe *b* and a closed pipe *c* connecting together the pipes *a* and *b* to their upper ends, an air-reservoir *g* having connected to it the lower ends of the pipes *a* and *b*, a pump *h* for circulating the water or other incompressible liquid, and a blower *i* for delivering the air to be compressed to the downward pipe, substantially as described.

847,587. ROCK-DRILL. BRADFORD H. LOCKE, New York, N. Y. Filed April 16, 1906. Serial No. 312,046.

Claim.—A rock-drill having a longitudinal channel and a series of lateral openings therefrom at frequent intervals along its length back of the drill-head, whereby the drill can be successively sharpened without closing the openings other than that next the head.

847,590. ROCK-DRILLING-MACHINE CHUCK. SIGISMUND R. J. MAYNARD, ALDROVAND V. T. MAYNARD, and FRANK GALE, Fordburg, Transvaal. Filed Nov. 13, 1906. Serial No. 343,299.

847,729. ATTACHMENT FOR VACUUM CLEANING SYSTEMS. GEORGE CLEMENTS and JAMES M. HOSTLER, Chicago, Ill., assignor to Hygienic Renovating Company, a Corporation of Illinois. Filed April 4, 1906. Serial No. 309,801.

Claim.—A device of the character described comprising a base, a transparent dome carried by the base, an outlet-pipe opening at its upper end into the top of the dome and leading outwardly through the base, and an inlet arranged tangentially to the base.

847,785. AIR-PUMP. PAUL E. KLEINEBERG, Croton Falls, N. Y. Filed Feb. 26, 1906. Serial No. 302,920.

847,941. PNEUMATIC BUFFER. MELVILE P. HAYWARD, Quincy, Mass. Filed Feb. 13, 1906. Serial No. 300,920.

847,947. APPARATUS FOR REMOVING DUST. DAVID T. KENNEY, North Plainfield, N. J., assignor to Vacuum Cleaner Company, North Plainfield, N. J., a Corporation of New Jersey. Filed Nov. 29, 1901. Serial No. 84,058.

847,946. ROTARY AIR OR FLUID COMPRESSOR. CHARLES A. KAISER, Astoria, N. Y., assignor of one-third to Leo Flatow, New York, N. Y. Filed Feb. 10, 1905. Serial No. 245,157.

847,944. PRESSURE-REDUCING VALVE. JOSEF HUBNER and ISIDOR MAYER, Vienna, Austria-Hungary. Filed Feb. 19, 1906. Serial No. 301,917.

848,341. APPARATUS FOR MOISTENING AIR. HARRY BENTZ, Larchmont, N. Y. Filed Jan. 18, 1907. Serial No. 352,868.

848,255. PNEUMATIC ENGINE. EDWARD LEICHTER, Nevada City, Cal., assignor of one-fourth to J. C. Campbell, Nevada City, Cal., and one-fourth to John Bender, Hamilton, Ohio. Filed Jan. 24, 1906. Serial No. 297,544.

849,333. AIR-COMPRESSOR AND INTERCOOLER. JOHN G. LEYNER, Denver, Colo. Original application filed Oct. 1, 1902. Serial No. 125,539. Divided and this application filed Sept. 2, 1903. Serial No. 171,625.

849,229. ROCK-DRILL. FREDERICK E. GLAZE, Victor, Colo., assignor to The Eureka Drill Steel Company, Cripple Creek, Colo., a Corporation of Colorado. Filed Jan. 31, 1906. Serial No. 298,878.

849,187. SCRAPER FOR DISK DRILLS. EDWIN R. BEEMAN, Minneapolis, Minn., assignor to Monitor Drill Company, St. Louis Park, Minn., a Corporation of Minnesota. Filed July 26, 1906. Serial No. 327,946.

849,190. ANGLE-COCK FOR AIR-BRAKE SYSTEMS. JOSEPH A. BENNETT, Youngswood, Pa. Filed Nov. 7, 1906. Serial No. 342,398.

849,049. PNEUMATIC TIRE. LORWIN N. CATES, St. Louis, Mo. Filed March 28, 1906. Serial No. 308,590.

848,852. AIR-INLET VALVE. PATRICK H. REARDON, San Francisco, Cal. Filed Dec. 27, 1904. Serial No. 238,540.

848,775. AIR-COMPRESSOR. WILSON SELAKOSKY, White Haven, Pa. Filed Aug. 6, 1906. Serial No. 329,427.

848,271. VALVE CONTROL FOR PNEUMATIC ELEVATORS. GEORGE F. STEEDMAN, St. Louis, Mo. Filed March 12, 1906. Serial No. 305,654.

849,051. POWER-TRANSMISSION DEVICE. ALEXANDER CHURCHWARD, Pelham, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Sept. 6, 1902. Serial No. 122,382.

849,506. ROCK-DRILL. CHARLES E. SHADALL, Milwaukee, Wis., assignor of one-half to Frederick L. Horneffer, Milwaukee, Wis. Filed March 31, 1905. Serial No. 253,018.

849,550. AIR-BRAKE MECHANISM. CHARLES G. LUNDHOLM, Otis, Cal., assignor of one-half to Frank E. Davisson, Los Angeles, Cal. Filed July 16, 1906. Serial No. 326,515.

849,597. COMPRESSOR-VALVE. NIELS A. CHRISTENSEN, Milwaukee, Wis. Filed March 21, 1904. Serial No. 199,228.

850,128. PNEUMATIC KNEE-BOOT FOR HORSES. ROBERT C. BEVER, Worcester, Mass. Filed Feb 24, 1906. Serial No. 302,709.

850,181. PNEUMATIC CUSHION. VACLAV H. PODSTATA, Dunning, Ill. Filed April 21, 1906. Serial No. 313,033.

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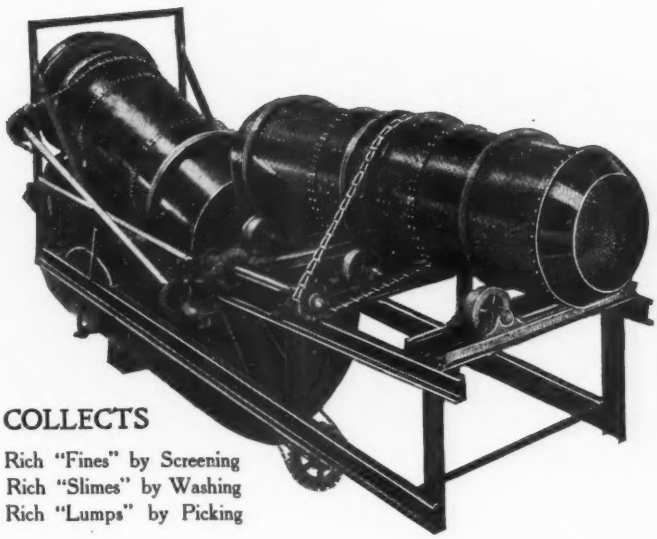

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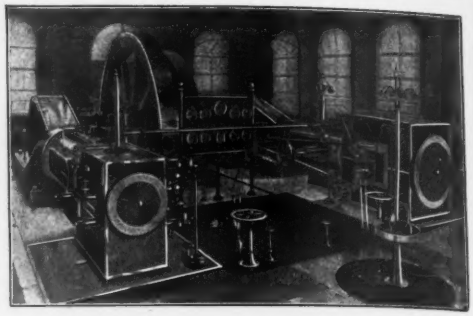

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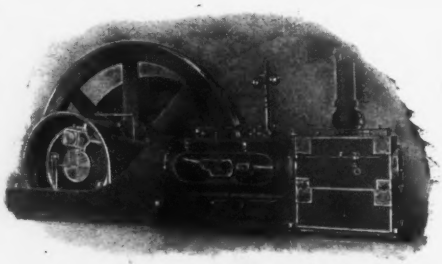

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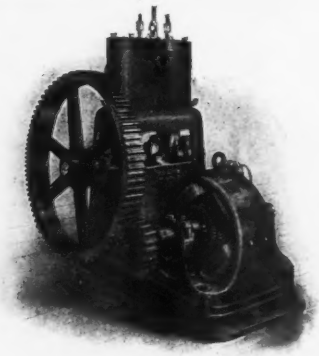

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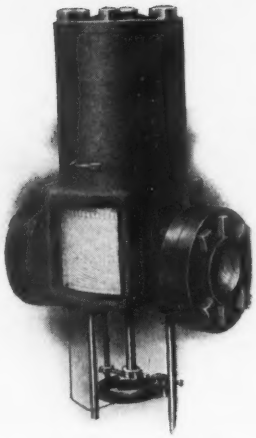

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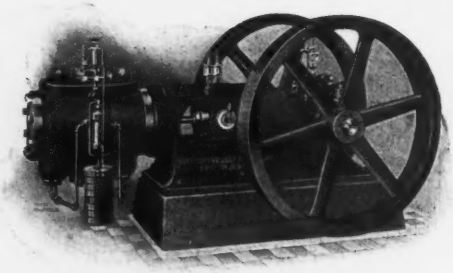

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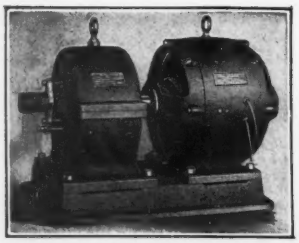

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INDEX TO ADVERTISERS.

American Diamond Blast Co..... 13
Blaisdell Machy Co., The..... 18
Boiler Maker, The..... 6
Brown & Seward..... 19
Industrial Magazine..... 3
Bury Compressor Co..... 15
Cameron Steam Pump Works, A. S.. 19
C. R. R. of N. J..... 5
Chicago Pneumatic Tool Co..Back Cover
Clark Co., The W. J.....Back Cover
Cleveland Pneumatic Tool Co..... 14
Cooper Co., C. & G..... 13
Coal..... 4
Comstock Engine Co..... 8
Curtis & Co. Mfg Co..... 13
Davis & Davis..... 20
Druckleib, C..... 18
Engineers' Club..... 4
Engineering Contracting..... 11
Engineering News..... 4
Engineering Magazine..... 7
Engineering World..... 2
Engineers' Review..... 1
Fiske Bros. Ref'g. Co.....Inside Cover
Goldschmidt Thermit Co..... 8
General Compressed Air House Cleaning Co..... 20
Goodrich Co., The B. F..... 17
Hanna Eng. Works..... 15
Ingersoll-Rand Co..... 16 and Inside Back Cover
Harris Air Pump Co..... 11
International Press Cl'p'g. Bureau.. 3
International Correspondence Schools 7
Lidgerwood Mfg. Co.....Inside Cover
Luce's Press Clip'g Bureau..... 5
McKiernan Drill Co..... 20
Marine Engineering..... 3
Modern Machinery..... 3
Mines and Minerals..... 7
J. W. Paxson Co..... 12
Porter Co., H. K..... 17
Powell Co., Wm..... 20
R. R. Gazette..... 2 and 6
Rix Compressed Air & Drill Co..... Back Cover
Romeike Hy..... 5
Roteng Engineering Co..... 15
Sargent Steam Meter Co..... 14
Sprague Electric Co..... 11
Stearns-Roger Mfg. Co..... 12
Sullivan Machy. Co..... 18
Technical Literature..... 21
U. S. Press Clipping Bureau..... 5
Westinghouse Traction Brake Co ... 20
Wheeler Condenser & Engineering Co.....Front Cover
Wiley & Sons, John..... 8

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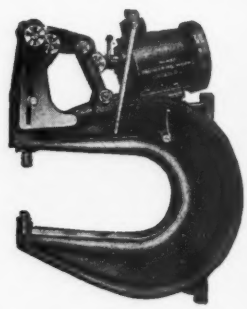

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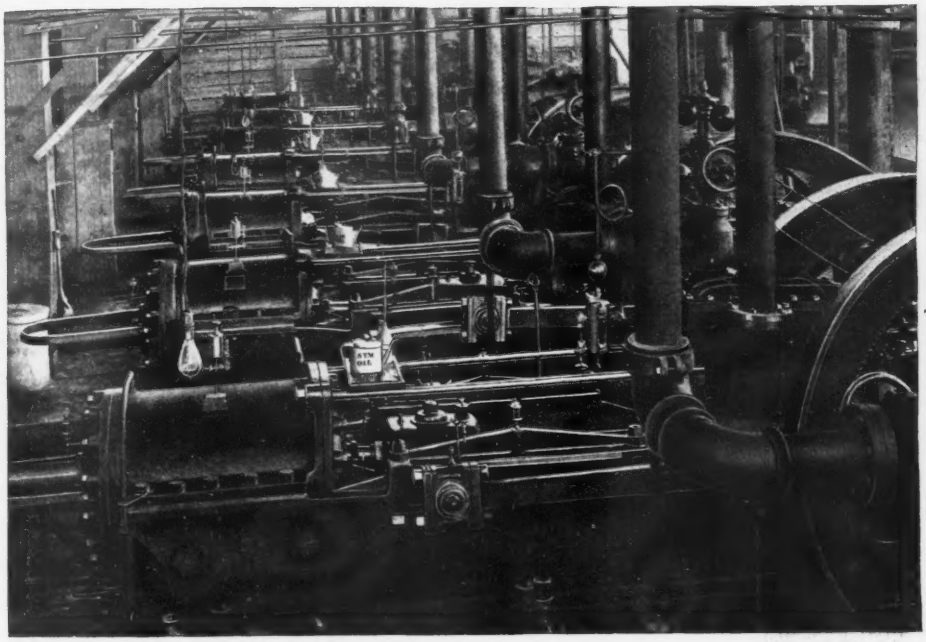

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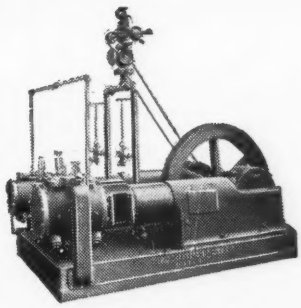

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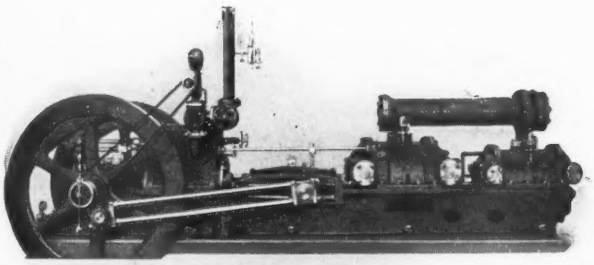

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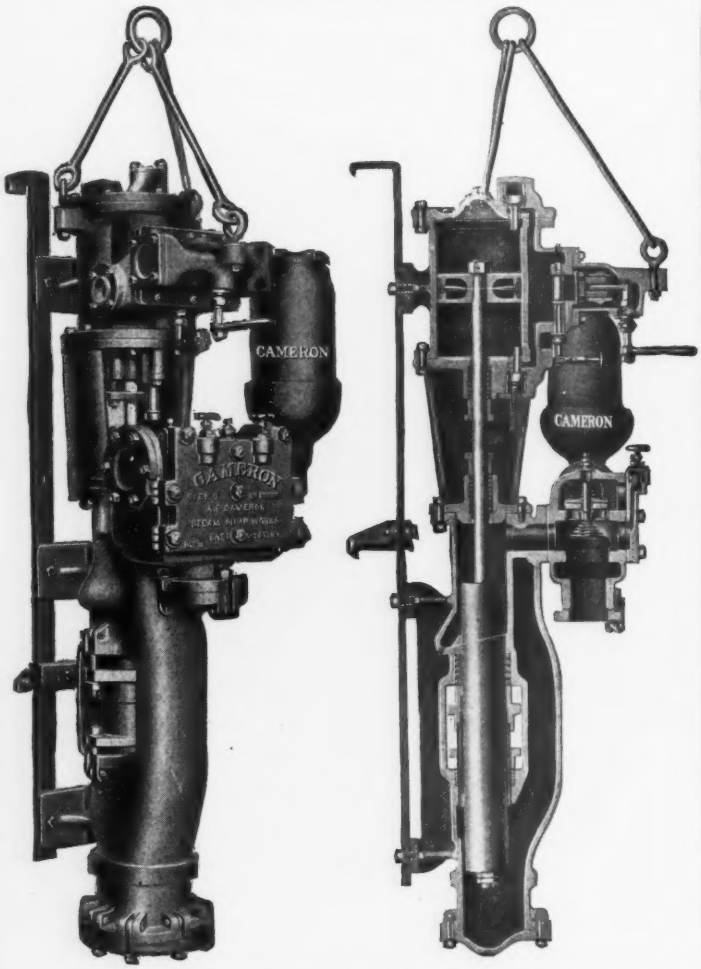

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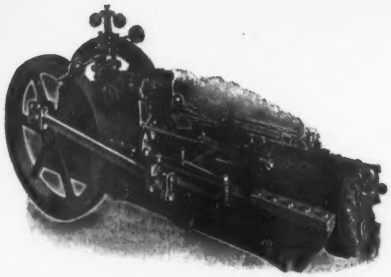

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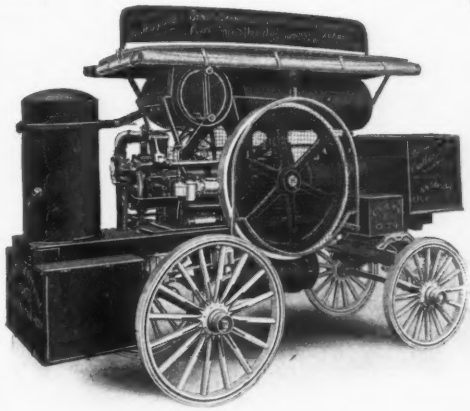

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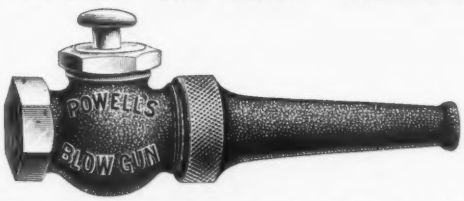

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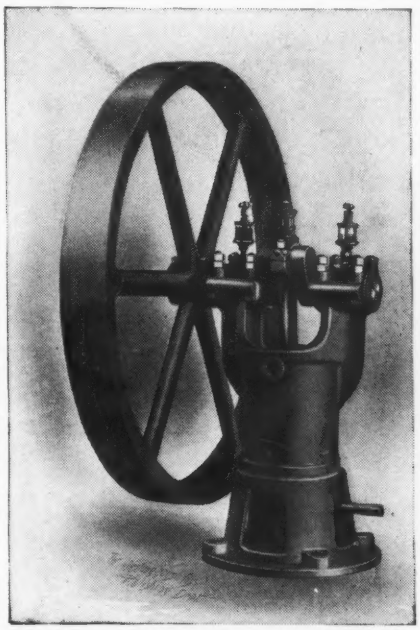

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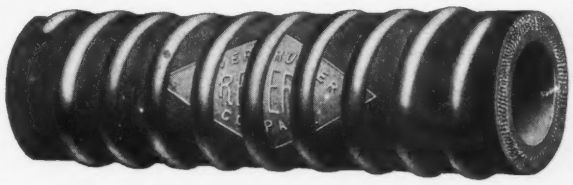

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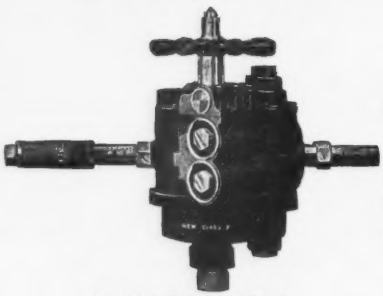

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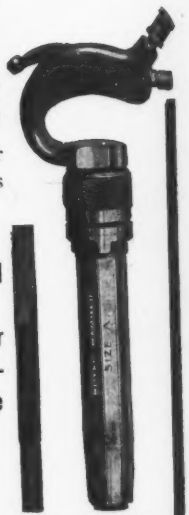

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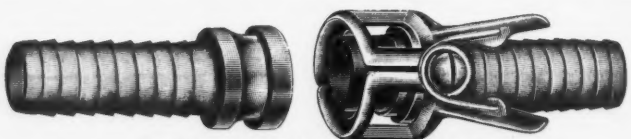

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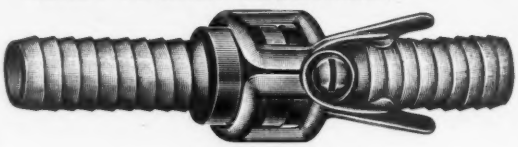

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